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POST-CONSUMER POLYOLEFIN PLASTIC RECYCLING: THE RESOURCE PLASTICS INC. EXPERIENCE

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POST-CONSUMER POLYOLEFIN PLASTIC RECYCLING

THE RESOURCE PLASTICS INC. EXPERIENCE

Report prepared by:

James T. Horn, P.Eng, Chairman
Resource Plastics Inc.

Report prepared for:

Ontario Ministry of Environment and Energy

DISCLAIMER

This report was prepared for the Ontario Ministry of Environment and Energy (formerly Ministry of the Environment) as part of a Ministry funded project. The views and ideas expressed in this report are those of the author and do not necessarily reflect the views and policies of the Ministry of Environment and Energy, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

Post-Consumer Polyolefin Plastic Recycling
The Resource Plastics Inc. Experience
Phase I and II

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ABSTRACT

This report covers Phase I and Phase II, Stages 1 and 2 which describes the redevelopment (see Report PIBS #2877) of a rigid polyolefin plastics recycling line and the design, construction and operation of a new polyolefin film plant incorporating innovative technology to recover post consumer, heavily soiled polyolefin films from the waste stream. Most of these films are less than 25 micron thick, a particularly difficult group of materials to process.

The modification of a rigid post consumer polyolefin recycling plant and the design and development of a polyolefin post consumer film recycling plant was partly funded by the Ministry of the Environment (now Ministry of Environment and Energy). The Agreement was made in furtherance of the MOE - Industrial Waste Diversion Program, to encourage waste reduction, reuse and recycling by industries.

The report describes in some detail the development of both these plants, the processes, the equipment involved and the subsequent successful completion of these two projects noted as follows:

- The rigid post consumer plant redesign and development polyolefin is discussed under Phase II, Stage 1.
- The polyolefin post consumer film line is covered under Phase II, Stage 2.

These two units are now diverting together, some 12,000 tonnes per annum of polyolefin plastics from landfills.

Unique Canadian technology has been developed with licensing opportunities, and a skilled employee base has been developed to expand this technology into other jurisdictions. The product quality levels are very high and a substantial export market has been developed.

The report further describes some spin-off technologies developed in conjunction with other Ontario based companies and some other opportunities developed through R & D programmes with four Ontario based Universities.

The report discusses the engineering, equipment and the operation of the plant pointing out successes and failures.

A list of DOs and DONTs has also been included to assist those who might read the report and consider an entry into this fascinating, albeit frustrating, business of recycling polyolefin plastics.

Executive Summary

Phase I and Phase II, Stages 1 and 2
Post-Consumer Polyolefin Plastic Recycling
The Resource Plastics Inc. Experience

Resource Plastics Inc. (formerly Resource Plastics Corp.) was the product of a technical and economic feasibility study conducted by Barry Wood and James Horn in the fall and winter of 1988-89. This study, partly funded by the Ministry of the Environment (MOE) under the Industrial Waste Diversion Program (IWDP) had as its goal the provision of adequate knowledge upon which an informed assessment with respect to the viability of investment in, and the operation of, a post-consumer polyolefin plastic recycling facility in Ontario could be made. Our study determined that the key factors for success were that:

- sufficient sources of recyclable post-consumer plastic materials needed to exist, e.g. household bottles;
- an adequate collection mechanism was required, e.g. Blue Box curbside collections;
- significant deficiencies in post-consumer plastic recycling technologies had to be overcome;
- markets for recycled plastics were immature, undefined and would need considerable effort to gain a toehold;
- long-term economic viability rested upon the development of higher-value end products;
- a high level of polymer knowledge and skills, coupled with substantial financial backing and capabilities were essential.

Completed in March 1989, the study nonetheless concluded that real opportunities existed for a properly focussed plastic recycling operation to survive and eventually prosper. Shortly thereafter, private investors were found, term and operating bank loans were arranged and a new company called Resource Plastics Corp started buying equipment in June 1989. Resource's initial focus was on selected post-industrial and post-consumer curbside plastics, processing the two main commodity rigid polyolefin resins, polyethylene (HDPE) and polypropylene (PP). At this time, an initial capital and process commissioning grant was obtained from the MOEE (referred to as the Phase I grant).

As we began processing materials in the spring of 1990, numerous collection, technical and marketing challenges became evident. While supplies were generally plentiful, the quality of the recyclables was a serious problem with respect to non-plastic and incompatible plastic contamination. The recycling technologies that we had purchased could deal with certain problems or degrees of a problem, but not nearly all of the processing challenges that appeared.

Market development and acceptance was a protracted affair. Materials were acquired for recycling in anticipation of sales that looked promising but never materialized. As well, in the absence of mandating or coercive pressure, brand users did not move to introduce post-consumer resin (PCR) in their product packaging.

We were losing a lot of money very quickly. The shareholders injected more money to keep Resource going. Our equity investment was now $3.5 million.

In the early winter of 1991, we started to get a few breaks. A number of equipment deficiencies were corrected. Dow Chemical Canada Inc. approached us proposing a fairly substantial supply-marketing arrangement selling PCR from high density polyethylene bottles and as a part of that agreement, concluded in March 1991, Dow assisted Resource to help purchase and install some $2.5 million of retrofits and new process equipment required based upon our experience. The MOEE also assisted in this significant process enhancement with a second grant (referred to as the Phase II, Stage 1 grant).

The retrofit was done in July 1991. In August we financially broke even for the first time and became profitable in the succeeding months. Our core business became recycling HDPE bottles from curbside collection operations, most notably Ontario's Bluebox system. The supply agreement with Dow allowed us to focus on the recycle manufacturing challenges while Dow focussed on distribution, technical support and marketing. It was a very beneficial relationship for Resource.

In the fall of 1991, we also started to more effectively recycle PE film, mainly from in store grocery bag collections. We also began experimenting with stretch film recycling. In this regard, we received a further grant from the MOEE IWDP (Phase II, Stage 2). These activities will form the basis of the second part of this report as the first section concentrates on Phase I and Phase II, Stage 1 grant activities only, which dealt primarily with rigid polyolefin post consumer plastic recycling.

The following section pertains to the activities and developments proceeding from the Phase II Stage 2 grant proposal. This grant proposal dealt specifically with the design and development of a plant to deal with very thin (<20 microns) polyolefin films, particularly stretch-wrap originating in the post consumer streams.

As noted above, development work started on processing thin polyolefin films with items like shopping bags and stretch wrap. Both of these items are produced in very large volumes and the visibility of these items in the market place raised serious concerns with the suppliers that if something tangible was not done to recover and recycle these materials, governments, under pressure from the environmental groups and the public, would take action to curtail these markets. It should be noted that shopping and stretch wrap were growing in volume at 7 - 10% per annum and in 1994 consumed together over 881,000 tonnes (1.9 billion pounds) of polyethylene.

Several major US film producers soon became aware of our activities and approached us to continue this work. They were prepared to take product back from us and to develop programmes where these materials would be used as a percentage of new production. This presented a major market opportunity if we could supply materials at the quality levels required

and at the volumes needed in their operations. Additionally, programmes were developing in Ontario to collect film from the Bluebox system. These films are very thin and difficult to process. Government personnel encouraged our efforts in this area as it was foreseen to be the next stage of plastic collection in curbside programmes.

In late 1991, it was obvious that the existing line, obtained from Germany in late 1989 and developed further in mid 1991 simply could not process such thin films to the quality required or at a viable level. Data obtained from the original part of the plant also proved that any plant handling recycled plastic would have to be very large. Estimated production levels on rigid should be in the order of 40,000 tonnes per annum and on film 20,000 tonnes per annum. Prototype plants could not be on this scale but plants built beyond the year 2000 will be to support the necessary overhead of professional technical support required and the additional sophisticated laboratory facilities

After the film plant design was essentially completed in 1992, the equipment was purchased from a number of suppliers who were deemed to be capable of supplying the best equipment for each unit operation. The film line was designed for a throughput rate of 2 tonnes per hour working on an 8000 hour year (3 shifts / 7 days). Construction commenced in 1993. The original projected cost was in the order of $5,000,000 Canadian. A great many unforeseen barriers created significant delays in the completion of the plant however and extensive overruns occurred. The plant was also constructed in two stages to prove equipment before proceeding with a parallel line. The plant was completed with full production capability in the early autumn of 1994 at a cost of $8,000,000. Many items were added in anticipation of operational problems that were envisioned but otherwise completely unforeseen.

Initial production trials on these lines indicated that the plant could produce exceptionally high quality recycled films and, as a result, the customer base expanded rapidly. In 1995, the customer list included many of the major US film producers and in Canada one or two significant film accounts are now taking materials produced on this line.

Production levels that started in the 22 tonne per day range have now risen to an average of 30 tonnes per day with a proposed target of 35 tonnes per day within the next few months although it is anticipated that some modest capital expenditures will have to be made to reach this next goal.

The film supply base is very different from the rigid bottle supply chain. Bottles are obtained primarily from curbside collection programmes whereas film is recovered primarily from the Industrial, Commercial and Institutional (IC & I) sector. Curbside film collection programmes could be very significant but they are very poorly organized at this time. Shopping bags are collected through the major grocery store chains but this source is much better organized in the US. Perhaps Canadians tend to re-use the bags for other applications more than people in the USA. Stretch wrap is primarily obtained through major distribution systems and the sourcing area includes the whole of the east coast of North America. Redemption bags, used to collect items in deposit law states, are also a source of feedstock, but only from US sources.

R. W. Beck and Associates, a US firm, has monitored the film recycling in North America and in 1994 reported that a total of only 77,000 tonnes was collected. Most of this did not end up in high value added markets such as new film applications as Resource is the primary producer in North America with a production capacity of 12,000 - 16,000 tonnes. The amount collected is less than 8% of the 3,950,000 tonnes (8.7 billion pounds) produced in the whole film sector and most of this is likely coming from the I.C. & I. stream. Products from Resource, all from post consumer streams, would cover only about 1% of the available film material in North America.

While the break-in period has been long and arduous we have succeeded in producing products of very high quality at prices that are generally under virgin resin pricing by some 15%. We can meet virgin specifications except for colour and generally feel that we have barely tapped the volume of the available material and the markets that can use these materials. California (pop. > 30,000,000) has a law that mandates 30% of PCR film into all trash bags sold in that state as of January 1, 1995. Additionally all plastic HDPE bottles sold there, not containing food products, must contain 25% PCR/HDPE. The Canadian Polyethylene Film Manufacturers Association has, together with the Federal Government of Canada, Environment Canada, developed an ECOLOGO programme to use PCR films in a wide range of products (see page 44). The Liquor Control Board of Ontario (LCBO) take-out bags also use significant volumes of PCR film.

These initiatives will drive the markets and have proven, beyond question, that PCR film can be viably used in a wide range of markets.

This plant has proven to be a successful prototype of future film recycling plants and has been accomplished with Canadian scientific skills working in conjunction with governments and industry.

ACKNOWLEDGEMENTS

Resource is emerging as a leading North American recycler of post-consumer HDPE bottles and PE film materials. Resource is deeply grateful to the MOEE as well as Dow Chemical for the financial support and encouragement they have consistently provided. In addition, the company wishes to commend The Government of Canada's Scientific Research and Experimental Development Investment Tax Credit program which has also contributed greatly to help fund Resource Plastics' technology development activities.

REPORT

This report has been prepared to fulfill the grant requirements of the MOEE Industrial Waste Diversion Program.

Post-Consumer Polyolefin Plastic Recycling
The Resource Plastics Inc. Experience
Phase I
Phase II, Stage 1

INTRODUCTION

Plastic waste can be divided into basically four categories, each category representing significant quantities of waste produced daily:

1) dry, clean, single resin materials, typically post-industrial scrap, e.g. trim scrap from bottle or bag-making operations;
2) dry, clean, multi-resin or laminated materials, typically post-industrial scrap, e.g. disposable diaper leg cut-outs;
3) dirty, wet, single resin materials, typically selected post-consumer waste, e.g. agricultural film, pallet stretch film collected from the consumer and the industrial commercial and institutional sectors;
4) dirty, wet, co-mingled resin materials, typically post-consumer waste, e.g. curbside rigid bottles, and film.

The first category of waste has long been recovered by plastics manufacturers. This material is often referred to as regrind. The second category of waste has rarely been recovered by manufacturers, typically due to processing/application difficulties arising from the multi-material nature of the waste. Likewise, the third category of waste has rarely been recovered, due to the requirement to remove the surface contamination and dry the plastic before re-extruding. The fourth category had not been recovered at all, due to absence of collection mechanisms, recycling technology deficiencies and end-product markets.

Resource Plastics' recycling objectives have, from the outset, focussed on wastes generated under categories 2 to 4. These categories represented untapped sources of potentially high-value plastics. In Phase I of our program, funded in part by the MOEE, we discovered by experience that we had acquired technology that could handle a number of wastes in category 2 and 3, but could not handle category 4 wastes at all. The Phase II, Stage 1 retrofit was directed at adding technology and processes that would permit handling a broader range of category 4 wastes.

The purpose of the first section of this report is to review each of Phase I and then Phase II, Stage 1 project activities from the standpoint of the key success factors; that are;

1) sourcing of recyclable plastic waste materials;
2) collection mechanisms, e.g. Bluebox curbside collections;
3) determining and remedying deficiencies in post-consumer plastic recycling technologies acquired;
4) market development activities;
5) development of higher-value end products; and
6) acquisition of skilled personnel and discussion of financial resources required.
7) documenting price supply/demand for rigid polyethylene bottles over the period from 03/92 to 12/95

PHASE I PROJECT ACTIVITIES

Equipment Selection

Resource ordered a plastics wash recycling line in the summer of 1989 from Herbold Germany for delivery in January 1990. This line's unit operations then consisted of:

a) a guillotine cutter, which received bales of material cutting material into slices. Undesired material was sorted in a small section conveyor before entering;
b) a shredder, whose counter-rotating lobes shredded plastic into hand-sized pieces;
c) a large inclined conveyor elevated material to;
d) a float-sink tank, where heavy materials such as stones, glass, metal and some heavy plastics sank; floating polyolefins were paddled over a weir to;
e) a wet granulator, where material was concurrently size-reduced and cleaned in a wet rotary cutting chamber; half-inch material then passed through a sizing screen to;
f) two friction washers, which quickly augered material upwards at a 45 degree angle against a countercurrent water stream; pulped paper labels and other grit are flung through the mesh screen that wraps these augers;
g) material was then mechanically and thermally dried;
h) material, in flake form, was then remelted, melt filtered and repelletized in an extruder operation. The material was then boxed and ready for sale.

Resource acquired extrusion equipment in the late fall of 1989 that permitted us to recycle both rigid and film flake material. This extruder, manufactured by EREMA Austria, also has a sophisticated melt filtration unit, permitting further cleaning of the plastic while in molten form.

The wash plant equipment was installed commencing in February 1990. The line was started up in April. Many startup problems arose. There were electrical and mechanical problems due to incorrect drawings and inadequate field support from Herbold. Automatic cycling routines in key units failed. Pumps were sized incorrectly and had to be replaced.

We experimented with numerous water filtration mechanisms and, until we ran post consumer plastic materials, we had very little understanding of what the requirements would be. Many failures were encountered, and the process piping reworked many times. The filtration devices that were ultimately selected must balance the effluent requirements of the municipality, the end-product quality needs which are affected by unfiltered solids in the water, as well as the operating and the capital costs associated with the various solutions available. A more extensive discussion of the capabilities of the wash equipment is included below.

Sourcing of Recyclable Plastic Waste Materials

As the EREMA extrusion line was the first equipment installed and operating, our early Phase I emphasis was on procuring and test recycling of category 2 waste materials. We tested our equipment capabilities on over 50 varieties of dry, multi-material wastes. Some principal examples included:

1) diaper leg cutouts, a laminate of PP and PE film;
2) PP snack food packaging scrap, e.g. chip bags;

3) PE snack food packaging scrap, e.g Tetra-Pak liners;
4) vacuum-metallized PP food packaging scrap, e.g. Hostess chip bags;
5) foamed PE pool cover insulation;
6) paper/PE food packaging, e.g. Tang orange drink packaging scrap;
7) acrylic-coated PP pasta wrappers;
8) carpet scrap;
9) woven PP tote bags;
10) PE/nylon food package laminates;
11) acrylic-coated PE food wrappers; and,
12) silicone-coated PP film, e.g. pressure sensitive label back-sheets.

With the startup of the wash plant in April 1990, we turned our attention to streams of category 3 and 4 materials for testing. Some of the category 3 materials we tested were:

1) PE agricultural mulch film;
2) PE greenhouse film;
3) PP onion bags;
4) PE boat shrink wrap; (polyethylene film used to protect power boats and yachts during winter storage)
5) PE bottle redemption bags;
6) PE leaf compost bags;
7) PE fibreglass insulation bags;
8) PP battery case scrap;
9) PE pails, e.g. used in fruits, printing, dough operations; and,
10) PE crates, e.g. chicken, bread, dairy.

We also began testing category 4 materials on a test basis. These materials included:

1) Ontario Bluebox mixed colour HDPE bottles;
2) natural HDPE bottles from US suppliers;(mainly milk and water bottles).
3) mixed colour curbside bottles from US suppliers;
4) Ontario Bluebox mixed colour HDPE bottles and wide mouth tubs;
5) post-consumer grocery bags.

RESULTS OF THESE INITIAL TESTS - COLLECTION, TECHNOLOGY AND MARKET ISSUES

Category 2 Materials

The biggest issue in collecting these materials was identification and separation of materials at the waste generator that we knew had no chance of working, from those that did. For example, in some plants we sought PE/PP laminate food packaging film and did not want polyvinyl chloride (PVC) coated films. Visually these materials can be hard to distinguish, and we were inadvertently supplied PVC/PE films several times. PVC is thermally unstable at temperatures

required to process PE and quickly degrades to produce hydrogen chloride gas which is very corrosive at elevated temperatures..

It was discovered that acrylic-coated PE and PP did not process well, as the acrylic coating burned, turning the PE an undesirable colour. Interestingly, metallized PP film processed well, with the thin aluminum coating (a few Angstroms thick) dispersing well. The material was otherwise of high quality. Colour would reappear however , in many instances, as an unfortunate roadblock to the use of recycled material. Brand-owner marketing departments wanted recycled material to meet virgin product colour levels.

Attempts to recycle paper/plastic laminates like Tang flavour crystal packaging using our extrusion equipment failed. The paper content overwhelmed the melt filtration capabilities of the extruder and started to char due to the PE melt temperatures of some 230 degrees Celsius. As a result, we began to evaluate other technologies to use the paper content as a composite filler which ideally could impart improved physical properties to the resin. We did some work with the University of Toronto Chemical Engineering Department (Dr. Ray Woodhams) and the Faculty of Forestry which had been doing work in this area. Dr. Woodhams is apparently close to commercializing his process of composite plastic/wood blends. We anticipate there could be a modest-priced opportunity to move finished product into this application area.

Carpet scrap was of interest to us, i.e. carpet made from PP, however it proved to be very troublesome to recycle due to the jute backing. The PP in the carpet is otherwise a high quality recyclable plastic source.

A similar problem arose attempting to recycle large PP tote sacks which are used in large numbers by food and chemical companies. The PP material content is quite recyclable; unfortunately, the nylon strapping and handles are totally incompatible. Also specialized shredding techniques would be required to process the tough constructions encountered in woven scrims.

We found the laminate of PE and PP as generated in disposable diaper manufacture to be a very recyclable material and a very useful material in thicker part injection moulding applications. A barrier to marketing has arisen due to the increasing use of gender-specific colours in the primary product. Markets for white recycled pellets are available, but pink and blue presented problems.

Category 3 Materials

With the startup of the wash plant, we began to experiment with recycling soiled, single resin streams of waste. Our efforts encompassed both film and rigid materials. One overriding lesson learned is that the different waste streams require handling techniques that are often unique to each stream. For example, greenhouse film came in long greenhouse length sections. They were exceedingly difficult to handle and feed into the recycling equipment as arrayed.

Agricultural mulch and leaf compost bags came in with heavy soil loadings to the point where some form of wash pre-treatment would be critical. These preceding materials were quite

processable as the film was of a heavy gauge. Unfortunately, the existing process water treatment process could not effectively handle the dirt loadings. The finished product, as a result, had a high incidence of dirt inclusions. Clearly, when designing the recycling line, one must focus on a limited range of materials and array the equipment to meet the infeed handling and processing demands.

PE bottle redemption bag recycling exposed us to our first thin gauge film challenge. The Phase I equipment granulation and drying train provided only very low output production rates due to the high surface area of material needed to be cut and dried. As well, this material presented the challenge of aluminum contamination in the form of caps and tabs from the cans carried in the bag and not emptied. This material carried through our entire Phase I process and was only removed in the extruder melt filters. The aluminum waste formed around the backer plates holding the melt filter screens, eventually blocking the entire melt flow. We had to develop an improved separation technology to remove the aluminum before it got to the extruder.

PE fibreglass insulation bags proved quite recyclable, but the trials pointed to the need for enhanced wash and separation capabilities. The fibreglass strands still left in the bag stayed through the wash process and contributed to a high incidence of melt filterscreen blocking.

We learned at this time that many makers of the packaging we were trying to recycle were unwilling to work with us to incorporate this material back into their process. We began to change our testing policy. If you do not take it back once we have recycled it, do not bother to send it in. We found our US customers much more willing to work with us than the Canadian companies. For a Canadian-based company, we were very disappointed.

In our grant application to the MOEE, we had expected that PP from auto battery cases would be a staple production item. We had naively assumed that the prewashed ground flake polypropylene coming from the various auto battery crushing plants would be free of residual lead. To ensure compliance with MOEE regulations, we independently tested flake from a number of battery recyclers. All the flake we tested proved to be well over the allowable lead content limits. Accordingly, we regrettably bowed out of the opportunity to process this material.

Our recycling of pails and crates proved to be only modestly successful. We were plagued by infeed handling issues; mainly from metal bale handles on the plastic pails, that bottlenecked our wash plant. As the large market for recycled crate and pail resin had a lower selling price than bottle grade resin at the time, recycle processing rates on this material had to be improved considerably to achieve commercial success.

We realized we had to be much more focussed on the streams of material we sought to run on the equipment. The process was not flexible enough to handle the range of materials that had been evaluated.

Category 4 Materials

By the spring of 1990, Dow Chemical had announced that they and Domtar would not be proceeding with a recycling joint venture. Now, without potentially overwhelming Dow/Domtar competition, Resource began to look earnestly at processing the Bluebox PE bottle materials on a trial basis. A large blow moulder, Plax Inc., also encouraged us to look at processing these materials.

We found the loads of Bluebox mixed plastic we recycled demonstrated significant potential variability in resin composition. The Bluebox mixed materials evaluated represented a wide range of plastic products. While 80% of the non-soft drink bottle portion is HDPE, HDPE materials themselves exhibited a wide range of physical properties that affected their end-use utility. Removal of aluminum and rubber compounds from bottle caps, seals and spray nozzles integral to the bottles emerged as a real problem.

The natural HDPE bottle streams proved readily recyclable. Marketability of these products was affected by colour tinting of the natural PE from coloured caps as well as the material's degree of cleanliness and residual odour.

We recognized that with the high number of one litre motor oil and other lubricant bottles in the waste stream some form of improved cleanup of the residual oils was required.

Processing grocery sack materials proved to be much more difficult than the films evaluated under category 3. The range of non-PE and non plastic contaminants was significant - PVC, nylon/PE meat wraps as well as newspapers, clothing, metals, glass, etc. Cutting and drying the thin films used in grocery sacks, now 13 - 18 microns (0.5 - 0.7 mil) thick emerged as a major processing issue.

In recycling both post-consumer bottles and film, we realized that we had to do much more in terms of enhancing our sortation of undesirable items prior to washing as well as significantly improving our in-process separation capabilities. This work became the subject of much of our effort in Phase II, Stage 1.

During Phase I of our program, we became an active participant in developing PCR quality criteria. We started to work on developing bale specifications (see Appendix B), finished product appearance rating scales and contributed to the ASTM committee proceedings regarding recycled materials.

The greatest interest in our Phase I activities was from potential customers in the US. While we gladly welcomed the business opportunities, it was somewhat frustrating given our Canadian base. Canadian plastic converters, e.g. blow moulders, bagmakers, had been largely inactive. This presumably reflects inaction at the brand owner level whom the converters serve, who will not move unless forced to do so by their customers, competition or government regulation.

By the end of our first year of operation, we had recycled about 1,600 tonnes of material. While the volumes were still modest, the range of materials we had tested was quite broad.

On the plus side in Phase I, we saw that good opportunities existed to build our bottle and film business on a North American basis provided we met quality and cost criteria demanded by the marketplace. We realized we had to work on improving the quality, the equipment, the process and the laboratory facilities. Also, in the light of our experience in handling and processing materials, and the direction market opportunities were heading (i.e. post consumer bottles and film), we decided to take a much more focussed view of those materials we would process in the Phase II, Stage 1 project activities.

Phase II, Stage 1 Project Activities

By the time Phase II, Stage 1 was underway, Resource had completed negotiating a significant supply-marketing agreement with Dow Canada for PCR from HDPE bottles. Accordingly, most of our Phase II, Stage 1 efforts focussed on improved recycling of these materials.

Accordingly, Resource approached the MOEE IWDP with an extensive proposal (referred to as Phase II, Stage 1) to do the following:

A *Characterize the Bluebox Materials Collected and Further Assess and Develop Their Marketability*

B *Investigate Resin Separation Technologies and Make An Assessment of Alternatives*

C *Improve Existing Recycling Facility Sorting, Separation and Processing Techniques To Dovetail With Mixed Rigid Bottle Collections. Specifically:*

a) Develop An Upstream Mixed Plastic Handling & Sorting Processes
b) Modify the Existing Recycling Line To Enhance Non PE Plastics and Aluminum Seal Separation
c) Improve The Handling and Reprocessing of Cleaned Bluebox Rigid Flake
d) Make Extrusion Additions/Modifications To Better Handle The Bluebox Materials
e) Improve Material Testing Facilities

This proposal was accepted by the MOEE under the IWDP and funding support was obtained. The following report section describes our Phase II, Stage 1 activities and findings in the above-noted areas.

A *Characterization of Materials Collected*

As previously noted, the loads of Bluebox mixed plastic which we have recycled have demonstrated significant potential variability in resin composition. As well, the risk was

confirmed that some reprocessing questions with respect to hazardous and non-plastic contamination might result if not checked by some prior control, such as visual inspection.

Also, quantification and assessment of the impact of the concentrations of PP and other mixtures on Bluebox HDPE blends and end-market usefulness was performed by Resource and Dow.

Conclusions re A

1. Development of a comprehensive, understandable, ***fair*** bale specification to serve as a guide to municipal suppliers was essential. We developed this specification based upon our experience (see bale specifications - Appendix B).

   Potentially hazardous materials were highlighted for exclusion, plus reasonable limits on non-HDPE plastic and non-plastic contamination were described. Also, freight terms, sampling, rejection procedures and explanatory notes were included. The specification has been well received by the operators of waste collection facilities.

2. Dow and Resource testing indicated that simple inclusion of tub material with bottle material would not produce a suitable product for bottle moulding purposes. The resulting material created was too flexible, resulting in poor top-load strength. Inclusion of small amounts of tub material was acceptable (2 - 3%), but certainly not at the proportions found in the Bluebox based upon our tests, i.e. over 10%.

3. Inclusion of small amounts of specific multilayer bottle material, notably the Heinz opaque bottle, a laminate of PP and EVOH (ethylene vinyl alcohol) did not present a problem at the levels found in the loads evaluated.

4. Raw materials supplied to our bale specification, produce a high quality product with properties demonstrably close to virgin material. The reuse potential is only affected by food contact issues and the brand-owner marketing issue of complete colour consistency.

B *Resin Separation Technologies - Assessment of Alternatives*

Sorting techniques are slowly developing, but in many aspects are still rudimentary. The industry must develop high-speed techniques to separate incompatible plastics.

We examined a number of older technologies such as hand-sorting, the float-sink system using water that our Phase I system employed, or a series of float-sink systems using solvents of various densities. Newer technologies that we tested or reviewed were; hydrocyclones, fluidized beds, star wheels, friction belting, trommels, walking tables, electronic sensing (chlorine detection), optical sensors, electrostatic separation, as well as combinations of the preceding.

Findings re B

1. Hand-Sorting

This method is extremely labour-intensive and prone to error. We calculated time-motion analysis in a properly designed sort environment. Our findings with respect to capabilities and costs indicate a variable sorting cost of 1.5 to 7 cents per pound, depending on the sortation required as a function of the range of materials collected and their intended end markets.

2. Float-Sink

We found that this approach is not 100% effective in separating incompatible polymers. Problems include, wetting characteristics, air retention, specific gravity range cross-over, filler and pigmentation induced specific gravity modification.

3. Solvent-Based Systems

While this Dow Chemical-patented process permits much more precise specific gravity separation, problems with solvent cleaning/disposal, plasticizer effects and excessive costs were evident. Environmental issues were also very difficult to overcome.

4. Hydrocyclones

This enhanced gravity separation technology, borrowed from the mining industry has proven itself useful in effecting a basic separation of polyolefins (PE & PP) from other incompatible, heavier than water polymers. It utterly fails to assist in sorting these heavier polymers (e.g. PET soda bottle flake, PVC shampoo bottle flake) from each other. Resource retrofitted these units in our line and got immediate product improvement over the previous float-sink approach. A recurring problem does exist with respect to uneven particle size distribution, which can affect the separation capabilities of this system.

5. Fluidized Beds

Only a basic investigation was done regarding this method. It would be of some value as an alternative to separating the polyolefinic fraction, but again the problem of separating the heavier incompatible polymers exists (i.e. PET & PVC).

6. Star Wheels

This mechanical separation approach is ideally suited for mechanically separating tub lid material from the stream. In addition, it is quite good at separating glass, dirt and other fines from the stream. The system is also self-cleaning and quite flexible in sizing modification.

7. Friction Belting

This approach uses the surface friction variation among polymers to effect separation. By tilting a specially designed rubber belt, plastic materials will either climb the belt or slide back down. Only preliminary research and experimentation has been done by Resource to date.

8. Trommels

We found that while these devices are in widespread use in various material recovery facilities, they are not a method of choice for handling rigid plastic materials because of material hangup in the trommel. Unfortunately, the trommel is not self-cleaning and the trapped material can be hard to remove.

9. Walking Tables

We reviewed the walking table technology employed at the Waste Management Inc. facility in Etobicoke. There could be potential for limited application of this technology in plastics sorting, but we lean to the friction belt/tilt table approach.

10. Electronic Sensing Techniques

a) X-ray backscatter

This method is used to detect chlorine, thereby detecting PVC bottles. This detection technology is performing well however, the greatest difficulties are singulation, i.e. arranging and passing one bottle at a time past the sensors and the air ejection system which sometimes fail to work.

b) Optical Sensors

Spectroscopic and/or refractive index techniques and infrared sensors are utilized. The differing opacity and properties of different polymers are calibrated and a microchip is programmed to air eject materials based upon the recognized material. Problems are still being encountered with the apparatus to line containers up single file in preparation for the sensor phase.

11. Electrostatic Separation

The University of Western Ontario has been working on this project with funding assistance from the MOEE. While early results were encouraging, we have not seen any recent reports of further progress.

C *Develop Existing Recycling Facility Sorting & Separation Techniques To Dovetail With Mixed Rigid Container Collection*

a) Develop Upstream Mixed Plastic Handling & Sorting Processes

Resource proceeded in October 1992 to enhance its ability to sort mixed curbside feeds in order to maximize value for the loads received. We designed and fabricated a custom sort line. The line is about 70 feet long, 15 feet wide and 12 feet high. Our primary focus will be on recovering value for PET inclusions and to separate natural HDPE from mixed colour HDPE bottles.

b) Modify the Existing Recycling Line to Enhance Non PE Plastics and Aluminum Seal Separation

We modified the Phase I wash line by installing an intensive wash tank, hydrocyclone separators and much improved mechanical driers. The results proved to be a success, with

finished product cleanliness, purity and dryness vastly improved. As well, our downtime experience with these new components, after correcting a fabrication flaw in one of the driers, has been excellent.

We still have a minor problem with residual aluminum from bottle seal tops as found in some household cleanser bottles. We can capture this contamination in our melt filters; however, we had to redesign our screen backing plates to minimize the effect of these materials.

c) Improve Handling and Reprocessing of Cleaned Bluebox Rigid Flake

We had severe difficulties dealing with the volumes of clean flake coming from the end of the recycling line. It was imperative that we attach buffer/feed silos to the end of the recycling line to control the throughput and automatically feed the extruders. The silos we have installed use special piping, anti-bridging devices and automatic level controls. Minor problems with level controls and anti-bridging devices have been largely corrected.

d) Extrusion Additions/Modifications To Better Handle Bluebox Materials

The large 160mm barrel diameter EREMA extruder that we acquired has worked quite well. It has been modified in many ways to improve its performance. The screw was redesigned to achieve a better balance between mixing and back pressure and output. The vacuum-venting system was doubled to draw off greater volumes of vapourized printing inks etc. We added special sections in the feed zone to get increased heat that enabled the extruder to deal with higher moisture levels and higher throughputs.

To better understand our operation, we have included a plant layout schematic and more detailed process description attached as Appendix C.

e) Improve Material Testing Facilities

Our laboratory now offers a good basic level of capability. We have sophisticated moisture analysis equipment, binocular hot-stage microscope, load frame with computer analysis for mechanical testing , statistical quality control software, a blown film extrusion line, ASTM mould for mechanical testing and an injection moulding machine, fume hood, explosion-proof oven, compression moulder, falling dart impact tester and, of course, melt flow and density measurement equipment. We are now in a position where we can supply our most sophisticated customer with all the basic test data required.

Findings / Conclusions re C

By the latter stages of the Phase II, Stage 1 program we were finally at a point where we could produce on-specification HDPE bottle PCR product consistently. At the same time, PCR users were starting to emerge. Drain tile and agricultural pipe makers started to consume increasing quantities of our material. Early leaders using recycled plastic back into bottles were the motor

oil suppliers, particularly Shell Canada, who now incorporate a 50% level of recycled content in their one litre bottles. Also, Procter & Gamble's efforts were stimulating household chemical competitors to begin to use recycled content in their bottles.

We have also successfully developed a tire rubber crumb/recycled plastic compound that has been used to manufacture backyard organic composters. The key technology here is the additive used to create a bond between the rubber and plastic materials.

For year two, the total weight of recycled plastic exceeded 3,000 tonnes. Year three processing was in the range of 6,000 tonnes. This was a substantial improvement over years' one and two, but further progress in our output capability with the modifications to the Phase I equipment in Phase II, Stage 1 is achievable.

Also, by this time, Ontario had become one of the leading recycling jurisdictions in the world with the Bluebox residential curbside recyclable waste collection program. Plastic waste, mainly PET and HDPE bottles, were now being collected in an increasing number of Ontario Bluebox municipal programs.
When the participation rates are extrapolated over total industry resin consumption statistics, the potential rigid and film recycling volumes are huge. Ontario now has in excess of 3 million Blueboxes in circulation, and this collection mechanism translates into rigid bottle material alone available for recycling of more than 10,000 tonnes per annum, if all municipalities participated. All municipalities collect the PET soda bottles, while currently just under 2 million Blueboxes in Ontario collect other plastics, principally HDPE bottles.

RECOMMENDATIONS & CONCLUSIONS RE PHASE II, STAGE 1

Collection Cost Uncertainty

Despite the Ontario Ministry of Environment and Energy 1992 municipal landfill diversion target of 25%, the enhanced financial resources and declared objective of Ontario Multi Materials Recycling Inc. Phase II (OMMRI2) to expand Bluebox mixed plastic collections and municipal garbage dumps daily being fed a diet of very recyclable plastics comprising at least 15% of waste measured by volume, a number of municipalities have been reluctant to expand plastic collections beyond PET beverage bottles, however, by the end of 1995 this situation was gradually changing.

Why this reluctance? Initially, because municipalities saw the cost of diverting plastics from landfill far exceeding the value of the recyclable plastic materials. This concern was largely dispelled by the joint Environment and Plastics Institute of Canada (EPIC)/MOEE Collection Cost Model Project completed in the summer of 1992 which demonstrated that the incremental plastic collection costs were reasonable ($190 per tonne) in relation to: a) the total costs of regular garbage collection avoided ($50 per tonne); plus, b) landfill consumption avoided ($50 per tonne); plus, c) revenue earned from the plastic recyclables ($75 - $300 per tonne depending upon market supply/demand). As one can see, even in a time of cyclical low prices for polyethylene

resin, HDPE bottle collection can be nearly a breakeven proposition (see Appendix D for Supply/Demand Trends, Rigid HDPE).

Markets... Consistent, High-Value End-Markets

To bring the just-stated economics into equilibrium or profit for municipalities, it is important that plastic recyclables be consumed in the highest value-added markets available in order to maximize revenue potential and offset costs for all participants in the chain - from municipalities to the recycler. If Bluebox plastic recyclables are consumed in plastic lumber applications, the municipalities' cost concerns would be borne out, as the real value in the plastic would never be realized through this application. As a result, the municipalities would never receive a reasonable amount to off-set the cost of their Bluebox plastic collection efforts, and plastic collections would have to be continually subsidized. As events unfolded, plastic lumber has largely failed and several municipalities became caught up in broad plastic collection programs in conjunction with these failed concerns. This has left the municipalities trying to market a mix of plastics that were very difficult to sort and utilize economically by processors such as Resource.

Municipal Plastic Collections - A Multitude of Material Collection Definitions

Another problem that has emerged with the evolution of plastic inclusions in the Bluebox is that there is little consistency among municipalities regarding the definition of which plastics will be collected. As noted above, plastic lumber operations contributed to the problems in this regard by going to municipalities with a broad collection specification that put the collection program ambitions well ahead of the technology that the plastic recycling industry has at this time.

The problem of wide variability in collection definitions used by Ontario municipalities needs to be addressed forthwith. We would propose a step by step approach; first, agree on a defined range of materials for collection now, within the economic capabilities of current collection, sorting and recycling technology; 2) concurrently, agree on a program of experimental development in sortation/recycling with time targets. Limit expanded plastic collections to those municipalities already doing so and use these collections to test new sorting technologies; and , 3) expand municipal collections to this broad specification as technology permits. With this program, there should be a regulation enforcing sponsorship of the development of sortation/recycling technology. This could be funded via a regulatory incentive for pursuit of waste reduction, reuse and/or recycling initiatives, e.g. advance disposal fees, which are refundable based on achievement of reduction, reuse and/or recycling targets.

The Need For A Plastics Sortation Facility

As a member of the Society of the Plastics Industry of Canada and an active participant in The Environment and Plastics Institute of Canada (EPIC), Resource Plastics Inc. has been a long time supporter of the need to have a buffer organization between the post-consumer plastic recyclers and the municipal suppliers. This buffer, referred to by many as SORTCO (a plastic industry sponsored sortation facility), is needed to provide municipalities with an assured market for plastic recyclables while not forcing the difficult task of resin sortation onto the many municipalities who have neither the sophistication nor the economies of scale to successfully sort the plastics in order

to market them. On the buying side, Ontario post-consumer plastic recyclers need better quality raw materials to survive.

In Resource Plastics view, the advantages of establishing a sortation facility vastly outweighs the disadvantages. If such a facility is not put in place, at least for say a five year transitional basis, the full range of post-consumer plastic packaging materials may be collected in Ontario but they may NOT be suitably recycled.

The imposition by government of punitive legislation seriously affecting the plastic packaging sector is quite possible. The industry must act promptly and effectively to positively shape possible government actions. We know a number of major participants in the Canadian plastics industry are similarly concerned and see a need for a sortation facility on a transitional basis until the plastic recycling industry and post-consumer plastic recycling technologies mature.

With the preceding concerns in mind and expressions of interest from some in the industry, we proceeded to prepare a proposal to establish and operate a post-consumer plastic packaging materials sortation centre on behalf of interested major participants in the Canadian plastics packaging industry. The goal was to collect and more effectively sort for high-value recycling a broader range of plastic materials. We needed to obtain a commitment from the industry that they would take stewardship for the sorted and/or recycled material by buying the sorted raw material or finished pellets/flake for resale to cover the costs of operating the sort facility.

Following our presentation, numerous meetings and discussions ensued. The industry progressed to a point where a plastic industry organization was established to move the project forward. While certain members of the industry were prepared to fund this corporation and move forward with a wholly-owned Resource Plastic Inc. subsidiary called MERIT Plastic Recycling Canada Inc. to develop a program of broad, sophisticated plastics sortation, not all major players would agree to join the coalition. Merit Plastic Recycling Canada Inc. would be the operating company supported by the coalition and managed by Resource Plastics Inc. on a contract basis. The project ground to a halt. It was simply impossible for Resource Plastics Inc. to go further without industry participation and stewardship support.

Some DO's and DONT's For Prospective Plastic Recyclers

1) Do have lots of equity funding in place before starting.

   We started our Phase I operation thinking it was well capitalized. On paper it was. The lesson we learned was that always budget for substantially higher capital and operating costs than hoped for. We had to inject a further $2 million of equity capital above the startup $1.5 million just to get started on Phase II, Stage 1 activities. Rigid plastic recycling is not a business for players that cannot raise sufficient capital to achieve production economies of scale of around 20 million kilograms per annum. At the same time, the recycler must produce very high quality product, so buying the best equipment is critical. By the end of 1993 Resource had over $6 million in share capital plus over $2 million in MOEE grant assistance.

2) DO have a full complement of engineering staff, from production to maintenance to materials to process.
We started off with only chemical engineering expertise. We now have on staff engineers with mechanical, process and metallurgy engineering experience. A range of professional experience and expertise is critical in this new industry. As well, we have three full-time millwrights and a journeyman electrician on staff.

3) DO recognize that the business cannot be built on the expectation of legislation alone.
When considering the expected marketplace, do not build financial forecasts on the premise that product prices will be boosted by mandating legislation. Assume that product will sell for no more than say 75% of virgin prices - if that!

4) DO expect significant US competition acquiring raw materials and in selling finished product.
All of North America is the marketplace and the competition for procuring raw materials and selling finished product covers this whole area. The quality standard that will be required to compete will be at the ISO 9002 level.

5) DO NOT embark in the plastic recycling industry without immediately having economies of scale, e.g. 20 million plus kilograms/year capacity UNLESS you have a niche market.
Prices are extremely competitive. Recyclers are competing in a marketplace dominated by huge virgin resin companies with substantial economies of scale. Post consumer plastics must compete in a commodity market.

6) DO NOT start before having a sound financial plan and a skilled financial professional staff.
Monitoring the startup of a new company in a new industry requires tight and constant monitoring of the operation, costing of activities and control of expenditures.

7) DO NOT trust the expertise of equipment suppliers who claim to have the answers, e.g. there is no such thing as a turn key plastic recycling system.
We learned the hard way that the only way recycling expertise is acquired is by doing recycling. While many equipment makers may claim they have a special insight, nearly all established recyclers design, engineer and build their own custom-designed wash recycling lines. These lines are designed to handle the process issues specific to the products the recycler deals with.

Process Overview, (Appendix C)

Initial Sorting

Bottle material, in baled form, is currently brought into the facility via the drive - in door near #4, where the bale is manually broken and sorted on a 35 ft. conveyor. Here stray metal, glass, paper, PET and the expected PVC is manually removed. This area has been totally revamped by the addition of more sort space, a bale-breaker and custom-designed sorting line to mechanize some

sortation tasks as well as streamlining to increase flows and move the non-processed materials off into balers for value recovery.

Film materials are currently loaded into the guillotine cutter (#3) for pre-cutting and delivery to the shredder. We are looking to move the cutter out-of-line as we now see that our grocery bag customer bales do not need precutting.

Size Reduction, Washing and Drying

Both bottle and film materials are fed by conveyor into the Herbold shredder where they are size-reduced to hand-sized pieces. These pieces are conveyed into the pre-wash tank (#5a) where heavy contaminants are removed. The largely polyolefin material, which floats in the pre-wash water is then paddle-fed into the large wet granulator. Here, the material is reduced to about ½ inch square pieces. There is a tremendous slurry cleaning action created here as the water-drenched materials are abraded during granulation.

The particle size permitted to continue is tightly controlled by pass-through screens in the granulator. The material is fed into high-speed, mesh-wrapped dewatering augers, which are mounted on an incline. These augers do the initial water removal as well as hydropulping paper labels. The removal of water and non-plastic contamination is vital to successful extrusion and repelletizing.

The major Phase II, Stage 1 retrofit involves the next phase. The material is now fed as a slurry to a new second cleaning wash and thence into hydrocyclone separators. The hydrocyclone technology, long-used in mining, works by creating a vortex which emphasizes the specific density variation between the light polyolefin faction and the heavy PET/PVC/other contaminants fraction. The hydrocyclones pass water-entrained polyolefins out the top, while removing the remaining heavy contaminants out of the bottom.

Next, the pure polyolefin stream will again be auger-dewatered and then passed to new multi-stage mechanical driers, which centrifugally spin-off most remaining water. Lastly, the material is passed to modified thermal driers where moisture levels are reduced to a level that the extruders can consistently handle with no downgrading of pellet quality.

Extrusion/Compounding

Film flake materials are airveyed into storage/feed silos for automatic loading onto the EREMA 160E extruder's feed conveyor. This extruder was specially modified in the factory in several modest but useful ways to improve its performance in pelletizing our film products. Clean rigid bottle flake is airveyed to storage silos (#8) for airveying to the 6 inch compounding extruder for direct pelletization or fed to the compounding blender (#9a) for custom colouring prior to pelletization. As well, Resource has a growing compounding business that involves recycled material that has been purchased from third parties.

The 2 EREMA 80's (80mm barrel diameter) (#12), smaller unvented extruders, like the EREMA 160, are used to directly process clean film laminates such as diaper scrap and vacuum metallized polypropylene film.

Finished materials are stored on and off-site in 500 kilogram boxes. Resource is installing bulk pellet storage and loading facilities.

PHASE II STAGE 2
POST CONSUMER POLYOLEFIN FILM RECYCLING

The first section of this report deals with the early endeavours of Resource Plastics Inc. to process rigid plastics polyolefin materials, primarily high density polyethylene (HDPE) as collected through municipal curbside collection programmes. This section, Phase II, Stage 2, deals with a post-consumer, polyolefin film recycling facility.

It soon became evident from a knowledge of the film industry and requests from our clients that polyolefin film recycling represented an extremely large waste stream. It did, however, also represent a major technical challenge to recycle this material to a quality level that would meet the standards of our clients and at a cost that would be acceptable to them and still be a viable activity for Resource Plastics Inc.

The engineering studies and the research and development carried out in other phases of this proposal were used to design a new, unique film processing system that would represent a state of the art technology for post consumer film processing, particularly when dealing with post consumer film of less than 25 microns (1 mil) thickness.

The American Plastics Council has studied the plastic waste streams in the US and reports that the annual plastic packaging waste generated in the US at almost 16 million tonnes (35 billion pounds). The population ratios could provide an appropriate number for Canada.

Polyolefin film represents a very large portion of this total and certainly represents the biggest hit if one is to remove these post consumer materials from the waste stream.

Four materials would make up the majority of the segment in question,

- High density polyethylene. Areas of use would include grocery sacks, food packaging material, release films.

- Low density polyethylene. Areas of use would include food packaging films, liner films, agricultural films, shrink wrap, general packaging films, stretch wrap, etc.

- Linear low density polyethylene. Applications include bubble cap films, stretch wrap, liner film, grocery bags, food packaging and general food packaging.

- Polypropylene. Applications include food packaging overwraps, textile overwraps, general clear packaging films.

These are materials that could be collected through the various sectors, both residential and the I.C. & I. sector, generating this waste. Obviously, trash bags represent a large volume of polyethylene consumption but such items would not normally be collected for recycling.

The use of stretch wrap alone would consume something like 450,000 tonnes per annum of polyethylene film. Discussions with major raw material resin producers and film suppliers all encouraged us to investigate this recycling sector intensively as it represents the biggest single waste stream for plastics packaging that can readily be recovered. Companies such as Mobil Chemical, Dow Chemical, Chevron, First Brands and Carbide encouraged our participation. We have since also had discussions with DSM (Dutch State Mines) and British Polyethylene Industries, both very large companies in the plastics sector and they voiced the same sentiments.

Dutch State Mines is a major polyolefin producer in Europe (sales ca $15 billion Canadian) who have been in the recycling business for 9 years. They stated that with respect to processing film under 25 microns (less than 1 mil) Resource Plastics is 5 years in advance of European facilities in terms of the technology employed.

Many problems had surfaced in the initial trials on the original line when we tried to process these materials. Debaling presented major problems and the shredding process was incapable of dealing with thin, pliable materials. The wet grinder blades were worn out after 72 hours. Bulking problems were plugging the transfer systems and the drying problems seemed, at times, overwhelming. A tonne of thin wet plastic film has an enormous surface area (1 pound of PE film has an area of 30,000 in^2 at 1 mil thick). While polyolefins are non-polar and water tends to bead on the surface, this area still represents an enormous challenge in drying these materials sufficiently so that they can be extruded into a quality product. Extensive investigations have been carried out on advanced drying techniques. Currently a combination of mechanical and thermal drying is used but other techniques such as microwave systems, heat pumps, fluid bed drying and desiccant dryers have been studied.

A number of equipment failures have occurred which would lead one to intensively investigate better film bale breaking technology, and rotary film flake dewatering drums have also created major problems due to their original design. Further studies have also shown that contrary to initial concerns, several items of equipment could now be constructed from epoxy coated mild steel rather than stainless steel.

Recycling plants have three major cost areas. Labour, energy and water! Less labour intensive techniques to move material are being investigated, mostly using industrial engineering techniques to simplify material handling into the feed end of the system.

Little can be done to further reduce energy costs, except for capacitors, and perhaps heat pumps to recover heat for the hot water cleaning process. Water costs are excessive. Green site plants should look at deep well systems. Deep well systems are not always available and a range of alternatives should be evaluated to reduce the water consumption and the associated costs.

Techniques to chill the process water, such as cooling towers or heat pumps should be investigated. The quality of the process water could also be improved by the use of more efficient

filters or membrane separation to remove fine entrained solids as well as detergents and surfactants.

When new facilities are constructed it is imperative that one considers product flow, building layout and especially ceiling height, utility layouts and laboratory location.

These plants generate a great deal of heat and for the comfort of the operating staff must be well ventilated. Electrical equipment and computer systems do not tolerate elevated temperatures and care should be taken to provide for suitable environments.

Laboratories must be temperature and humidity controlled to provide for standard conditions for testing. Quality targets are moving up at exponential rates and the need for adequate testing and control are vital. One should not overlook the need for very sophisticated laboratory facilities to meet customer requests.

An adequate laboratory should now include the following items as a minimum.

Basic Laboratory Facility List

Elmendorf Tear Tester
Drop Dart Impact Tester
Film Line Film Gauge Tester
Injection Moulding Machine with an ASTM Die (prepares samples for physical tests).
Differential Scanning Calorimeter (DSC) - determines different polymers by pyrolysis
(FTIR) Fourier Transform Infra-Red Spectrophotometer - polymer identification
Macbeth Colorimeter - measuring colour
Moisture Analysers , one for high moisture contents 1% and above and one for low moisture contents in parts per million
Melt Indexer - measures melt viscosity at zero shear - a measure of the molecular weight
Densimeter - measures polymer density
Computer - for processing information and SQC data storage
Glassware for general laboratory investigations particularly related to pollution control.
Magnified Light for visual QC
Binocular Microscope, 400X with a hot stage
Balances 1-2 Decimal Places 1-4 Decimal Places
Tensile Tester and Software Package
Statistical Quality Control Pack Software
Fume Hood
Compression Moulder

Obviously, other facilities would be highly desirable, but this would represent a basic list.

Needless to say it is imperative that very skilled people be employed to use these facilities and to interpret the results. Laboratories must be fully manned to accommodate 24 hr, 7 day production.

Maintenance is a major issue in recycling plants. The incoming materials often leave a great deal to be desired and by their very nature contain a lot of dirt and non-plastic materials. While much of this is removed before entering the wash lines some items do get into the system and create severe problems. Maintenance represents a major cost in spare parts, ongoing preventative maintenance programmes and in emergency breakdowns. It is critically important to maintain high production rates to satisfy quality sales and profitability. Training and a detailed knowledge of the equipment is also a very important issue in this area.

We are now in a position to cover most shifts with a person responsible for maintenance.

Research and Development is a very important part of our programme, although it ends to be r and D. The experimental development part tends to be very large because most of our problems must be resolved over a fairly short time frame.

We are members of the Ontario Centre for Materials Research and we work primarily with those Universities in the OCMR that have significant polymer R & D programmes. This would include the Universities of Toronto, McMaster, Waterloo and Queen's. Attached is a typical wish-list that we have sent to these Universities and to the National Research Council laboratories in Ottawa and Boucherville PQ (see appendix E)

It is significant to note that through the OCMR we have developed a new technology programme for laser drilled extruder filter plates, an exceedingly difficult problem. These plates have previously been produced in Germany and are very costly ($12000 - 18000 per pair). The screens are 19 inch diameter, hardened steel plates about 0.03125 inch thick. They have 750,000 laser drilled tapered holes in them approximately 0.005 inch diameter. These filter screens will filter approximately 500,000 kilograms of molten plastic before they have to be changed. We were using them at the rate of one pair per month. The Ontario Company that can produce them here will not only obtain our business but likely obtain additional sales from others using similar equipment to ours in North America and they have also developed spin off technologies from this base for other industries. This represents new technology and high technology jobs for Ontario.

We have now found a way to clean the screens economically and have installed a cleaned set in the extruder and ran an additional 500,000 kilograms through it thereby reducing the cost to about $6000 per month. Further work is being carried out on these plates such as improved materials of construction and innovative coating systems such as nitrogen ion implantation.

In addition, based upon engineering studies done at McMaster University and working with a firm in Hamilton, Ontario we would choose to have some of the equipment for any new lines built in Ontario through skilled people that have worked so diligently with us in the development of this facility.

When the film line was proposed, we selected Hatch Engineers and Associates in Mississauga to assist us in the development of the water conservation systems and the civil engineering requirements. This interaction means that Canadian engineering firms can now actively work with us to design and develop advanced film recycling plants that can operate with greater throughput efficiency and superior quality products with a reduced capital cost on a similarly sized facility.

All of these points indicate that based upon the R & D conducted in this plant in Brantford we can construct new facilities for a lower capital cost than this one. They would produce a high quality recycled film at rates approaching 1.6 - 2.0 tonnes per hour for a capital cost (not including site or building) for between $6-7 million Canadian. These plants operate on a 3 shift, 7 day basis for an 8000 hr year. The annual capacity would be 13-16000 tonnes per year. Consideration has also been given to enlarging the production rates on these lines but it is inhibited by the ability to deliver sufficient material efficiently to the feed end of the line. It would appear to be more prudent to install parallel lines. This would also help to maintain high production levels should one line or one section be down for maintenance.

THE PROJECT

The overall objective was to design, construct and operate a facility to accept heavily soiled, post consumer polyolefin plastic film waste. The proposed line was to separate unwanted material, thoroughly wash and dry the film and to extrude a polymer pellet that would meet the quality specifications of our clients.

The studies were also to include estimates of capital costs to replicate such a plant and to determine the operating costs to prove the viability of such an undertaking.

A substantial list of research and development topics were identified for further study between our professional staff and University, government and industrial laboratories.

Investigations were also ongoing to identify possible spin off ventures that could establish new markets and/or possible vertical integration.

PROGRAMME IMPLEMENTATION

The programme was implemented by investigating suitable equipment components that would be required based upon our past experience and the differences that were observed in experimenting with film materials, as opposed to rigid plastic bottles, from the waste stream.

The proposed design can best be explained by discussing the implementation, equipment selection, installation/commissioning etc. on a unit operation basis.

The project economics, successes and failures as the project evolved will be covered on a broader basis to provide some continuity to the whole process.

PROCESS OVERVIEW (see Appendix F)

The process is divided into eight unit operations, listed as follows;

a) infeed and initial cutting
b) prewash and granulation
c) washing and rinsing
d) hydrocyclone separation
e) mechanical and thermal drying
f) water filtration system
g) Programme Logic Control - Process controller
h) Extrusion
I) Programme Logic Control - sampling, blend, storage

a) *Infeed and Initial Cutting*

Stretch - wrap with a tacky surface, when compressed in a high compression baler becomes extremely difficult to separate into individual pieces of film that can be inspected for contamination before it enters the prewash and the granulation stage.

Other types of film can be much more readily separated. A major problem, during the winter months however, is that the wet bales freeze and are particularly difficult to debale.

These problems led to an investigation of suitable bale breakers for baled film scrap. These bales weigh on average 400 kgs but range from 140 kgs to 1400 kgs. Obviously these weights can severely physically punish equipment.

The bale breakers selected were designed and built by Pierret, a Belgian firm, and are commonly used to debale waste textiles.

They work, but not well, and they are a source of major maintenance. The machines are not sufficiently robust to accept the impact of heavy bales being dropped into the hopper from the hydraulic lifting platforms. The bale size and the shape also means that the bales often hang up over the oscillating breaker knives. In future designs one should look seriously at bale size reduction and fluffing before it enters such a system.

There are two parallel feed lines that each feed into a train consisting of bale breakers, guillotines, prewash tanks, granulators and dewatering screws, coming together in a buffer silo. The facility layout will show this configuration (Appendix F).

The film exiting from the bale breaker is manually checked for contamination and unwanted material is removed. If it is just an unwanted colour, these are retained and included in a colour run.

The film is now fed through a guillotine cutter where the film is chopped. These were chosen as rotary shredders do not work particularly well with long strands of film.

Originally there were two guillotine cutters in sequence. The first one cut the film into French bread stick shapes. These shapes entered a second guillotine at right angles to the first one and were sliced into chunks about the size of a muffin:. These muffins were airveyed into the prewash system. Operating and maintenance problems led us to remove the second cutter and dispense with the airveying system. The current feed accepts the chopped sticks and they are carried by a conveyor built into the prewash tanks.

b) *Prewash and Granulation*

The prewash system is an elevated tank where the plastic film is conveyed by the water flow and paddles, forcing the plastic waste under the surface to wet it, remove heavy entrained materials such as dirt or bits of glass and metal prior to it entering the granulator.

The granulator on the original line presented a major problem in cutting thin films (<20 microns). Cutter blades were worn out after 72 hours and production time was lost due to the 4 - 6 hours required for a blade change.

Many granulator manufacturers were approached and we ran actual trials with thin plastic waste shipped to them.

We selected a Previero granulator, made in Italy. These people have had considerable experience in this area and the equipment has generally performed very well, however we have made several operational changes with these machines. Cutter blade to stator gapping is closely monitored, as is blade to sizing screen distance.

The blade changes are now at 144 hr intervals and because there are two infeed lines with redundancy built in we can maintain full production during blade changes (4 + hours).

With respect to blade life we are working within the OCMR programme with several Ontario Universities to investigate new techniques to extend blade life.

These include, advanced blade metallurgy, ion implantation, zirconium coatings etc. Obviously this is an extremely complex problem with little or no historical R & D data to work from. Advances coming from this programme will permit Ontario companies to benefit from such R & D in new markets and job creation.

The two Previero wet granulators as supplied were not nickel plated in the key wet areas where corrosion could occur. This was an error on our part for not recognizing this deficiency in the beginning. The rotors were removed and nickel plated to overcome any potential corrosion problems. There have been problems related to blade gapping. The

targets are gaps consistently from 0.004" to 0.006". Due to the blade investigations previously discussed these are now gapped 0.003" to 0.009". When the investigations into these problems commenced we were 0.004" to 0.025" which was unacceptable. Obviously this is the source of further R & D. These wet granulators were sized to wet grind ca. 1900 kgs per hr, each. They have not been run at their full capacity as yet because we do not have extrusion capacity to process 2 x 1900 kg per hr.

c) *Washing & Rinsing*

The wet granulated flake is augered upward at a 45° angle using a high speed rotating screw closely fitted with fine screening. Fresh water flushes entrained dirt particles away from the film. The two screws, one from each granulator line dump wet flake into a buffer silo. This unit has sufficient capacity to keep the downstream components running a full rates while a granulator blade change occurs.

This silo has been the source of many maintenance and production problems. The screws moving the material forward frequently jammed and the compaction or bridging that occurred with the thin wet granulated films created many problems. These have just been recently corrected by putting a reversing mechanism on the screws to release the jammed material and by installing a conical cover over the screws so that the weight of the material above the screws does not cause them to overload. These corrections could not have been foreseen in the original design and represent one of the major hurdles in the development of this new technology.

The discharge from this silo enters an intensively stirred slurry tank. Warmed water recovered from the cooling streams in other sections of the plant thoroughly washes the high density slurry. The discharge from this tank proceeds to a hydrocyclone separation of any material with a specific gravity over 1.0. The polyolefin plastic materials processed in this plant all have a Specific Gravity of less than 1.0 and are carried overhead in the water stream to the next stage.

There have been some problems with the hydrocyclones as designed where some of the lighter materials have been discharged through the bottom orifice rather than from the overhead stream. This is controlled largely from the balance of the system and has been corrected. The washed, separated flake is then dewatered in a mechanical drying step prior to being discharged into a second wash tank.

This double washing system has proven to be very effective in providing an extremely clean flake, a vital quality specification when processing such post consumer waste materials.

In general, except for the rotary drum mechanical dryer this system has worked very well. The rotary drum dryer is similar to two others that will be discussed in the section on mechanical and thermal drying.

d) *Hydrocyclone Separation*

Hatch Engineering designed the hydrocyclones along with the water filtration system. Generally speaking, these units have worked well. The hydraulic balances through the system are one of the critical control factors that determines much of the success of the operation of the entire system.

e) *Mechanical and Thermal Drying*

As noted in the introduction, 1 lb. of polyethylene 1 mil thick has a surface area of 30,000 in^2. This plant runs film under 25 micron (one mil) therefore it is clear that when processing film at 1 - 2 tonnes per hr, the amount of water that must be removed is enormous. The specification on the final product for water content is 750 parts per million. The target for water entrainment exiting the thermal dryers is between 3 and 7%. Anything in excess of this slows production in the extrusion system due to the heat required to volatilize the additional water. As noted previously, polyolefins are not hygroscopic but a great deal of water is carried through on the surface of the film.

The spin dryers are designed to remove much of this water after the film has been washed and passed through the hydrocyclones. These drums consist of a rapidly spinning chamber encased by a screen. The original design on these units proved to be a disaster. The shaft reduction, the shaft metallurgy and the design of the bearing housings created a series of failures that necessitated the dismantling of these units and a complete redesign and rebuild. We contacted the Mechanical Engineering group at McMaster University and with their assistance completed a new design of the shafts and the rotating elements as well as the bearing mounting.

We had these new units built in Hamilton and they have performed very well. It would be our intention to build such facilities in Canada for future needs.

Thermal drying has generally performed well but could present a major bottleneck as the throughput is increased in this line to design capacity. The programme to modify this to provide for more adequate drying is to move the drying flake through a double set of rotary valves so that the hot, high-dew point air, can be vented before entering the second drying stage. The furnaces that supply the heated air have sufficient capacity to accommodate the additional production.

f) *Water Filtration System*

A great deal of investigation was required to develop a water recirculation and filtration system that would keep capital costs as low as possible but still address the problem of water consumption. Plastic recycling wash plants can consume water in large quantities. Total recirculation systems are certainly available but they are expensive and consume a lot of space.

The system that we installed also eliminates the need for expensive systems to control the chemical oxygen demand (COD) and the biological oxygen demand (BOD) in the waste waters.

The process was designed to require about 60 GPM (gallons per minute) of make-up from a fresh water source to keep the COD's and BOD's to acceptable limits.

It was later noted after the plant had started up that both wash lines were using about 100 GPM together.

The extrusion lines were using almost this same amount of water for cooling purposes and this water was going to sewer. The system was reworked to divert this heated clean water to the make-up side thereby reducing the need of water required from the city mains.

Additionally, this water raised the wash temperatures from 10°C to 25°C which substantially improved the washing performance on the soiled plastic film.

There are currently four levels of water filtration before it is sent to the sewers.

The primary hydrocyclones remove some of the solid waste. The secondary hydrocyclones remove the rest of the solid waste before the water is returned to the wash process. Two vibratory screens are used to further filter out the waste materials, consisting mostly of paper fibres. Two vibratory screen processes further filter out waste solids. One, a large rectangular screen, and lastly a final filtration to prevent solid waste from entering the sewer system.

Water is a major cost in plastic recycling plants and every effort has and will continue to be made to reduce this cost. It is also a fundamental responsibility of the owners of these facilities to work diligently on water conservation and to adopt an overall stewardship of all the resources used.

g) *Process Control PLC*

In the original design of the plant, the need for a programme logic controller (PLC) was not foreseen. As construction progressed it became evident that this would be an essential part of the process. We contracted with a Canadian Engineering firm to develop the software for this system. Essentially one person can operate the entire line. The system is self diagnostic and provides for efficient and sustained operation of the line. It provides for better productivity and reduced operator needs but it does require a higher level of skills training than previously required.

The development of the PLC was a very expensive addition to the capital cost and required a massive development effort on the part of our professional staff to set up the

programming. It has proven to be a vital part of the line design and we regard it as one of the unique features of this design.

h) *Extrusion*

These flaked polyolefin films are extremely difficult to feed into an extruder as they bridge. Crammer feeders which auger the feed into the hopper do not work with these sticky fluffy materials. The Erema extrusion lines are well designed to accept flaked film feeds as they are fitted with an agglomerator at the feed end of the extruder. Load monitors call for material feed on a belt conveyor as required. This agglomerator also removes up to 6% of surface moisture by the addition of heat in the form of kinetic energy delivered by a rapidly rotating blade.

There are two Erema 160 mm extrusion lines fitted to the film processing configuration. Each line is capable of extruding up to 2000 kgs. per hr. into pellets. The evolution of this unique extruder design has been rapid, with the first line fitted with a cycling melt filtration system while the newer lines are equipped with a large area laser drilled continuous filter. The lines operate at 3000 to 3500 psi with the final rejection point for filter change at 4000 psi.

The original line was designed to draw in agglomerated film flake into the 32:1 L/D (length to diameter) extruder, melt the feed and at about the halfway point on the screw, enter a depressurized zone where a double vacuum system drew off any volatiles, originating from inks, adhesives or other contamination. The melt was then repressurized into a feed zone before entering a 2 stage filter with the ability to cycle and back flush sensed by pressure transducers. The screen packs are composed of a series of wire mesh screens, consisting of Tyler mesh screen (see Glossary) configuration as follows: 20/40/3 x 150 Double Dutch weave/40/20.

The polymer melt is extruded through a spaghetti die where an underwater face cutter produces the pellets. These extruders also have internally cooled screws to provide for the critical temperature control required.

The newer Erema extruder is fitted with a specially designed continuous laser drilled filter having approximately 750,000 holes in a 19" diameter hardened steel plate. Two of these plates are mounted about 1 1/2" apart with a scraper assembly continuously wiping the contaminated plastic from the face of the plates and augering it into a central discharge port.

This contaminated material is later recovered, reground and used in less critical applications. It amounts to 2 - 3% of the processed material. In discussions with the extruder manufacturer it was decided to mount the vacuum degassing zone just downstream from the filters to prevent flooding at this section which can otherwise occur when the filters start to plug and the back pressure increases. The feed zone downstream

from the degassing ports then provides a very constant pressure at the die face thereby eliminating pressure variations at this point that could cause a variation in pellet size, another important quality control aspect.

We experienced a great deal of difficulty during the first year of operation with the laser drilled filter. The design had many shortcomings and plate metallurgy needed to be redone. Hardening was another problem. These filter plates can filter about 500,000 kg over about 1 month of operation. The costs, however, are high as these laser drilled plates have been obtained from Germany and we have only recently developed an Ontario source. The hole sizes are about 0.005" or 100 micron, equivalent to an 150 Tyler mesh size. There is an opportunity with newer laser drilling technology to build a filter with over 200 Tyler mesh equivalent. Our Ontario manufacturing contact can also vary the metallurgy and drill smaller holes. It also appears that the cost will be lower. This contact has been developed through the OCMR and it seems that there could be many new spin-off and export opportunities based on the same technology.

Through the National Research Council (NRC) in Ottawa we have also developed a technique to solvent and ultrasonically clean the plates so that they can be used for 2 months instead of one month thereby processing 1,000,000 kilograms using the same filter plate. These trials have just been completed and with further advances we may be able to further extend the filter life and significantly reduce the costs of filtration.

We have just recently redesigned the screws for these extruders and we can now achieve higher output rates and better temperature control.

i) *PLC Bulk Control, Sampling and Blending*

It has been imperative to examine the incoming film to this facility. It is extremely difficult to ascertain exactly what is contained in the bale visually and we have resorted to more sophisticated techniques to provide these data. Incoming film waste is checked by a Differential Scanning Colorimeter, a very useful tool that can quickly identify a polymer that may be laminated or extrusion coated to the polyethylene base stock. We also used other techniques such as FTIR Spectrophotometer examination to further identify any problems that may interfere with the quality. This examination of the incoming feed leads into the quality control of the outgoing material.

The bunkering system was designed to transfer material from the extrusion lines to 700 kg sampling bunkers which automatically remove approximately 0.5% of the stream to provide a statistical average of the material being processed for Quality Control testing. The materials proceed through increasingly sized bins of 1400 kg - 4500 kg.

The materials undergo a final Quality Control check from the 4500 kg bins before being transferred to 100 tonne storage silos. Each of these 100 tonne silos is dedicated to a specific product (i.e. film, natural or coloured and rigid, natural or coloured) to avoid any

cross contamination. When ready for shipment the materials are passed through a 50 tonne blending silo and then shipped in 500 kg boxes or by bulk truck or bulk rail.

This whole bulk handling system is computer controlled with unique Canadian developed software. It is set up such that only qualified laboratory personnel can transfer the product though the system and to the eventual customer thereby eliminating any chance of cross contamination. Blending is a critical aspect of quality control as the final customer then receives and can process a product in his plant that is completely uniform and follows published specifications. The laboratory is staffed on three shifts, seven days to meet the plant production schedules and the customers needs.

PROJECT ECONOMICS

This plant was originally designed to process 2 tonnes per hr of thin polyethylene film. It has, at times, exceeded 1.3 tonnes per hr. but more development work will have to take place to reach the ultimate design target. The original design was estimated to cost about $5.5 million Canadian. The actual line as finally built cost about $8 million Canadian.

There were many reasons for this over-run and the major items are listed as follows:

- The system had many options to allow for the unknown nature of the feedstock for the line
- The customers were continually changing and upgrading the quality specifications required.
- There evolved a need for a large capacity blending system to homogenize the pellets to meet customer specifications.
- There were delays in the installation in part due to the lack of up front engineering.
- Extensive modifications were carried out during construction to provide for thin film processing.
- Additional modifications were made to deal with the sticky nature and extremely thin gauges (less than 15 micron) of stretch films.
- Development of the control systems and the logic systems required to effectively manage the line. There was not a recognized need for these in the original concept.
- More development work than expected was required to operate the systems that were largely proven in other industry sectors.

Hindsight is a harsh teacher. Current knowledge suggests a new line handling thin films with improved performance could be built in the range of $6 - 7 million Canadian that would process 2 tonnes per hour (16,000 tonnes per year).

Detailed cost studies have been developed by computer modelling and these data have proven to be fairly accurate in actual operating line studies. The original proposal to the MOEE suggested film could be processed for $0.37 - $0.40 per kg.

A detailed analysis of potential cost savings, and studies regarded as readily achievable could reduce this cost to the $0.30 - $0.32 Canadian per kilogram range. These costs would not

include the purchase price of the feedstock, nor the packaging and freight of the outgoing materials.

Gains in experience in dealing with film materials and the supply base available suggests that subsequent facilities can operate with a much lower variable cost structure. A graph illustrating recent supply demand price history is appended (see Appendix G). One can see the volatility in commodity markets and the impact upon companies such as Resource.

RESULTS AND CONCLUSIONS RE PHASE II, STAGE 2

It is felt that the original objectives proposed to the MOEE have been met and exceeded. A quality level has been achieved that is regarded by our clients here and in Europe as second to none when handling heavily soiled very thin polyolefin feedstocks.

Production targets have been increasing monthly and an average of all film materials is approaching 35 tonnes per day whereas in the spring of 1995 we were in the 22 tonne per day range.

This design can be modified to adapt to a wide range of polyolefin feedstocks which comprise close to 80% of the non-durable waste stream in North America.

As noted in the section on project economics, many changes were made, albeit costly, that have made this plant a success.

In any developmental project, failures become opportunities. We eliminated sections of the process, changed the handling of the materials from air conveyors to mechanical conveyors in some cases and have been forced to redesign entire pieces of equipment to make them work as we expected.

Off-the-shelf lines do not work as the most useful experience can only be gained by working with the equipment on a day-to-day basis. Plants work best when they achieve steady state conditions and it has taken us a long time to reach this plateau with repeatable production levels every day approaching design conditions.

We are constantly reviewing the process to identify bottlenecks. As one is removed, others are identified. This is only possible with a full scale line as we have not been able to see many of the problems in laboratory conditions.

In closing, one can only reiterate the comment of one of the engineers from Dutch States Mines in the Netherlands who have been in a similar business for nine years but not in thin polyolefin film recycling. After touring the facility and discussing the product quality he said "You are five years ahead of anything in Europe".

DOs AND DONTs

DOs

1. Design the building to be long and fairly narrow.
   Feed in at one end, out at the other. Keep everything in a straight line where possible.
2. Locate the plant on a rail siding with good road access to minimize transportation costs.
3. Provide for adequate laboratory space and equipment.
4. Put the plant in a building with 10 - 14 m clearance minimum to allow access and reduce heat entrapment.
5. Build the facility to proper scale, 40,000 tonnes per yr (2 lines, Brantford size).
6. Operate the plant 24 hours a day, 7 days a week with time of use contract for electrical energy.
7. Locate close to a free or very low cost supply of water such as a river or a well.
8. Hire a competent core group of technical staff to ensure, low cost operation, good engineering with timely and realistic goals.
9. Provide adequate lead time in building the system to ensure that engineering work can be done.
10. Define feed stock and customer needs to minimize capital cost.
11. Locate as close to the supply base as possible - 800 - 900 km radius.
12. Have agreements with suppliers that can benefit by the collection of the waste plastic materials.
13. Expect the quality of feed stock to decrease as you reach further into the supply base.
14. Vertically integrate the organization to allow for higher value added products. Selling plastic pellets means competing in a commodity market with the usual price fluctuations. Every effort should be made to produce products from these pellets to take advantage of the added value and to smooth out price fluctuations. One could consider automotive parts, agricultural and horticultural containers and other moulded items like crates, boxes etc.
15. Have access to capital to assure the success of the project.
16. Have a long term vision for the project.
17. Participate with all the R & D sources you can identify.
18. Maintain a close relationship with governments and industry organizations.

DON'Ts

1. Do not underestimate the size of the task.
2. Do not expect one equipment supplier to build the facility.
3. Do not expect a stable market condition for supply and sales. The industry is still in its infancy and supply and demand are not always in balance.
4. Do not expect legislation to pull the industry along.
5. Do not expect the primary plastic producer to be a major customer.

The following tables describe the quantity of waste diverted, the source of that waste and the end uses for these materials after they were recycled through either the rigid polyolefin line or the polyolefin film processing line.

See Tables Attached:

TABLE I

RESOURCE PLASTICS INC.

Finished Post Consumer Resin Pellets
Waste Diverted (See Table II)

Volume Changes

	93 / 94	94 / 95	% Increases
Rigids (HDPE bottles)	4,360,100 kg	5,481,200 kg	+ 26
Film (LLDPE. LDPE & HDPE)	2,455,000 kg	6,304,000 kg	+156
Total	6,815,000 kg	11,785,200 kg	+ 72

Rigid bottle materials are sourced in Canada and the US. Natural colour HDPE milk and water bottles are sourced almost exclusively in the US and consist of homopolymer HDPE. The coloured bottles from curbside collections are manufactured mostly from copolymer HDPE. These are important distinctions in the applications for these recycled materials.

Film materials are obtained primarily through the I.C. & I. stream and primarily from large distribution centres. (ie: Walmart, Canadian Tire)

TABLE II

RESOURCE PLASTICS INC.

Received/Processed Waste Materials (Waste Diverted From Landfills)

	93 / 94	94 / 95	% Change
Rigids			
Rigid Post Consumer Resin Pellets Produced	4,360,100 kg	5,481,200 kg	+ 26
Waste Material Utilization Efficiency %	80	85	+ 5
Waste Material Processed (diverted from landfill)	5,450,125 kg	6,448,450 kg	+ 18
*Waste To Landfill	1,090,025 kg	967,250 kg	- 12
Film			
Film Post Consumer Resin Pellets Produced	2,455,000 kg	6,304,000 kg	+156
Waste Material Utilization Efficiency %	75	85	+ 10
Waste Material Processed (diverted from landfill)	3,275,000 kg	7,416,500 kg	+126
*Waste to Landfill	820,000 kg	1,112,500 kg	+ 36

*Studies are underway to find alternate applications for much of this material going to the landfill. The objective is to reduce the impact on the landfill and to reduce operating costs.

SOURCES OF WASTE POLYOLEFIN MATERIALS - DIVERTED FROM LANDFILLS

Rigids:

a) Sourced in Canada and the US

b) Predominantly from municipal Material Recovery Facilities (MRF) involved in curbside collections of household products.

1. HDPE Blow Moulded Bottles (SPI Designation #2 on the underside of the container)

Examples:
- Detergent bottles
- Bleach bottles
- Fabric softener bottles
- Shampoo bottles, etc.
- Water Bottles
- Vinegar Bottles
- Milk Bottles

Films:

a) Sourced in Canada and the US

b) Sourced via brokers, waste haulers and directly with I.C. & I. generators

c) Generators are grocery chains, multi product distribution centres e.g. Wegmans, Food Lion, Canadian Tire, Wal Mart. Automotive manufacturers e.g. GM, Toyota. Food processing plants e.g. General Foods, Kelloggs, Coca-Cola, Pepsi-Cola.

MARKETS/APPLICATIONS FOR POST-CONSUMER RESIN PELLETS

Rigid:

Windshield washer fluid bottles
Anti-freeze bottles
Motor oil bottles
Fabric Softener bottles
Shampoo bottles - multilayer
Household cleaning solution bottles
Bleach bottles
Corrugated Pipe - building, construction & irrigation products
Horticultural Products
Sheet for Thermoformed products - Truck body liners
Automobile heat and A/C ducting
Hidden automotive moulded parts (i.e. spare tire covers)

Film:

Blended PCR Virgin materials for bags, (garbage, shopping etc)
Coextruded consumer garbage bags
Bubble cap films, for fragile packaging
Liners, protective film for furniture etc.
Waste containers (tote bins)
Carpet overwraps
Industrial garbage bags
Specialty degradable film products, landfill covers
Flexible corrugated tubing
Stretch wrap
Grocery bags
Liquor store bottle bags

Typical customers for rigid materials

- Graham Packaging Canada Inc. - motor oil bottles
- Owens Brockway - HIC* bottles, soap products
- American National Can of Canada - motor oil bottles
- Polybottle - automotive products
- Eastman Kodak - toner cartridges
- Dow Brands - HIC* bottles
- Colgate Palmolive - soap product bottles

*HIC - Household and Industrial Chemicals

Typical customers for film materials

- Alte-Rego (Can.) - trash bags
- PCL (Can.) - shopping bags, liquor store bottle bags
- First Brands (US) - garbage bags
- Owens Brockway (US) - squeeze bottles
- Presto Products (US) - stretch film
- Carlisle (US) - construction film
- Environmental Products Inc. (US) - biodegradable landfill covers

HEALTH & SAFETY

Plants handling waste materials present some unique hazards. The exposure to waste materials can endanger the health of the employees such that if one has a scratch or is splashed in the eyes with liquid there is the danger of contracting Hepatitis B. To avoid such infections all employees are vaccinated against Hepatitis B.

Safety glasses are required as are safety shoes and hard hats.

Burns can result from contact with hot equipment surfaces such that proper clothing is required. Insulated gloves are worn to protect the operators from such hazards.

A safety committee was established to make sure that safety issues are quickly dealt with. Accidents, no matter how minor, must be immediately reported and the situation rectified to prevent a reoccurrence.

Incoming material has sometimes contained hazardous objects such as syringes. If this occurs, the supplier is immediately contacted and steps are taken to prevent it from happening again.

Containers that have contained motor oils and agricultural chemicals are not permitted in the bale specifications and if found are separated on the line before entering the recycling line.

Environmental Choice[M] Program

Environment Canada, Ottawa, Ontario K1A 0H3

ECP-69-94

Polyethylene Plastic Film Products

Programme Choix environnemental[M]

Environnement Canada, Ottawa (Ontario) K1A 0H3

PCE-69-94

Produits de pellicule de polyéthylène

uant to paragraph 8(1)(*b*) of the Canadian ronmental Protection Act, Environment Canada is ed to publish the following national guideline on lethylene plastic film products under the auspices of nvironmental Choice[M] Program.

En vertu de l'alinéa 8(1)*b*) de la Loi canadienne sur la protection de l'environnement, Environnement Canada a le plaisir de publier la directive nationale concernant les produits de pellicule de polyéthylène dans le cadre du programme Choix environnemental[M].

Environmental Choice Program is designed to support ontinuing effort to improve and/or maintain onmental quality by reducing energy and materials mption and by minimizing the impacts of pollution ated by the production, use and disposal of goods ervices available to Canadians.

Le programme Choix environnemental a pour but de soutenir les efforts constants déployés en vue d'améliorer ou de maintenir la qualité de l'environnement en réduisant la consommation d'énergie et de matières, et en minimisant les incidences de la pollution engendrée par la production, l'utilisation et l'élimination des biens et des services offerts aux Canadiens.

sed on a review of currently available life cycle mation, the product category requirements will ice an environmental benefit through a reduction of rial entering the solid waste stream and ervation of resources, including energy.

D'après les renseignements dont nous disposons actuellement au sujet du cycle de vie, les exigences relatives à cette catégorie de produits auront des effets bénéfiques sur l'environnement par une réduction des matières résiduaires et la conservation des ressources, y compris de l'énergie.

ycle review is an ongoing process. As information chnology change, the product category requirements be reviewed and possibly amended.

L'évaluation du cycle de vie des produits est un processus continu. À mesure que nous disposerons d'autres renseignements et que les techniques évolueront, les exigences relatives à cette catégorie de produits seront révisées et éventuellement modifiées.

onment Canada anticipates that manufacturers or ters of polyethylene plastic film products which rm to this guideline will apply to the Environmental e Program for verification and subsequent authority el the qualifying products with the Environmental e EcoLogo[M].

Environnement Canada prévoit que les fabricants ou les importateurs de produits de pellicule de polyéthylène conformes à la présente directive feront une demande à Choix environnemental aux fins de vérification pour obtenir l'autorisation d'apposer l'Éco-Logo[M] de Choix environnemental sur leurs produits.

Interpretation

In the following guideline:

Définitions

1. Les définitions qui suivent s'appliquent à la présente directive:

gricultural film" means film, whether or not in rolls, cto preserve fodder, as a replacement for glass in ehouses, as row covers, hay bags, silo caps, trench overs, plant bed covers, and for composting;

«pellicule agricole» Pellicule, en rouleaux ou non, utilisée pour conserver le fourrage, pour remplacer le verre dans les serres, pour les chenilles, les sacs de balles de foin, les couvertures de silo et de silo tranchées, les couvertures de planches de culture, et pour le compostage;

nvironment anada Environnement Canada

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"agricultural mulch film" means film, whether or not in rolls, used in the ground, under the root systems of plants, to facilitate crop cultivation;

«paillis de plastique» Pellicule, en rouleaux ou utilisée au sol, sous le système radiculaire, faciliter la culture;

"construction film" means film, whether or not reinforced, laminated, supported or similarly combined with other materials, used in the construction industry (e.g., tarpaulins, drop sheets, and wind screens), excluding products intended for use as vapour barrier films;

«pellicule de construction» Pellicule, qu'elle s non renforcée, laminée, pourvue d'un suppo combinée à d'autres matériaux de façon semb utilisée dans l'industrie de la construction (bâches, toile de protection et pellicules pare-br l'exclusion des produits destinés à servir de pell pare-vapeur;

"consumer" means a household, or industrial or commercial establishment or institutional facility;

«consommateur» Résidences ou install d'industries, d'institutions ou de commerce;

"drum and other liners" means film, whether or not in rolls, and whether or not reinforced, laminated, supported or similarly combined with other materials, intended for use inside industrial shipping containers;

«garnitures de fûts et autres garnitures» Pellicul rouleaux ou non, qu'elles soient ou non renfo stratifiées, pourvues d'un support ou combin d'autres matériaux de façon semblable, desti servir de garnitures internes dans des cont d'expédition industriels;

"garbage bags" means film bags or sacks manufactured for intended use as a container to hold, store or transport materials to be discarded, composted or recycled, including, but not limited to, garbage bags, composting bags, lawn and leaf bags, can-liner bags, kitchen bags, compactor bags, and recycling bags;

«sacs à déchets» Sacs de pellicule destinés utilisés comme contenant pour contenir, conser transporter des matières destinées à être re compostées ou recyclées, et notamment, les ordures ménagères, les sacs à déchets de pelou sacs de garniture pour contenants, les sacs po les sacs de compacteurs et les sacs de recyclage

"grocery carry-out sacks" means film sacks or bags intended for the conveyance of grocery products;

«sacs d'épicerie» Sacs de pellicule destin transport des produits d'épicerie;

"HDPE" means high-density polyethylene;

«HDPE» Polyéthylène haute densité;

"household post-consumer material" means material collected from curbside and depot collection programs serving individual households and apartments;

«matières de postconsommation domes Matières obtenues par les programmes de cu sur le trottoir et dans des centres desserva résidences mono ou multifamiliales.

"industrial stretch wrap" means film that is stretched during application and shrinks without the use of heat to unitize loads of goods shipped on pallets;

«pellicule rétrécissable industrielle» Pellicule étirée au cours de son application et qui se sans application de chaleur pour l'assemblage de denrées expédiés sur des palettes;

"LDPE" means low-density polyethylene;

«LDPE» Polyéthylène à faible densité;

"LLDPE" means linear low-density polyethylene;

«LLDPE» Polyéthylène linéaire à faible densit

"PFMAC" means the Plastic Film Manufacturers' Association of Canada;

«PFMAC» Plastic Film Manufacturers' Associ Canada;

"polyethylene plastic film product" means a product made from LDPE, LLDPE, or HDPE film;

«produits de pellicule de polyéthylène» Produ de LDPE, LLDPE ou de HDPE;

t-consumer material" means a product which has
d its end-use at the consumer level, has been
rded by the consumer, and would, unless diverted,
the waste stream. This includes household
consumer material;

-consumer material" means materials generated by
dustrial process that would, unless diverted, enter
aste stream. This includes, but is not limited to,
ged or defective materials, overstock or obsolete
tories from manufacturers, distributors, and
salers;

cled material" means post-consumer material and
nsumer material. It does not include
oducts of an industrial process that can be, and
arly are, used in either the same process, or in a
ent process, except that proportion which
nated as post-consumer material and
nsumer material;

l sacks" means film sacks or bags intended for
nveyance of non-grocery retail merchandise;

nk film case wrap" means film that has been
ned during manufacture and reverts to its
al dimensions when heated; and

hically non-recyclable" means that, after use,
cts or materials can not easily be diverted from
aste stream and recycled into new products or
ges, due to material selection, lack of technology.

Category Definition

This category includes all polyethylene plastic
roducts as further defined in the sub-categories in
ction. The sub-categories are:

garbage bags;
grocery carry-out sacks;
retail sacks;
industrial shipping sacks;
shrink film case wrap;
industrial stretch wrap;
drum and other liners;
construction films;
agricultural films; and
agricultural mulch films.

«matière de postconsommation» Produit dont le consommateur s'est débarrassé après en avoir fait un usage final et qui aurait normalement rejoint le flux des déchets s'il n'en avait été détourné. Inclut les matières de postconsommation domestique.

«matière de préconsommation» Matière provenant d'un procédé industriel et qui aurait normalement rejoint le flux des déchets si elle n'en avait été détournée, notamment les matières endommagées ou défectueuses, les matières provenant des stocks périmés ou superflus des fabricants, des distributeurs et des grossistes.

«matière recyclée» Matière de préconsommation ou de postconsommation. Sont exclus les sous-produits d'un procédé industriel qui peuvent être, et qui sont habituellement, remis en fabrication selon le même procédé qui a servi à leur production, ou un autre, sauf la proportion qui provient de la matière de préconsommation ou de postconsommation.

«sacs de magasins» Sacs de pellicule destinés au transport de denrées autres que d'épiceries;

«emballage de boîtes en pellicule rétrécissable» Pellicule étirée au cours de la fabrication qui retrouve ses dimensions initiales sous l'effet de la chaleur, et

«techniquement non-recyclable» Produits ou matières qui, après usage, ne peuvent pas être facilement détournés de la filière des déchets et recyclés en de nouveaux produits ou emballages, à cause des matériaux employés, de l'absence de technologies, etc.

Définition de la catégorie

2. La catégorie visée comprend tous les produits de pellicule de polyéthylène tels qu'ils sont décrits dans les sous-catégories mentionnées ci-après :

a) sacs à déchets;
b) sacs à épicerie;
c) sacs de magasins;
d) sacs-ballots industriels;
e) emballage de boîtes en pellicule rétrécissable;
f) pellicule rétrécissable industrielle;
g) garnitures de fûts et autres garnitures;
h) pellicules de construction;
i) pellicules agricoles, et
j) paillis de plastique agricole.

General Requirements

3. To be authorized to carry the EcoLogo **polyethylene plastic film products** must:

(a) meet or exceed all applicable governmental and industrial safety and performance standards; and

(b) be manufactured and transported in such a manner that all steps of the process, including the disposal of waste products arising therefrom, will meet the requirements of all applicable governmental acts, by laws and regulations including, for facilities located in Canada, the *Fisheries Act* and the *Canadian Environmental Protection Act* (CEPA).

Notice

In order to minimize the solid waste burden, conserve resources, and reduce quantities and impacts of toxic substances and other pollutants associated with packaging, the Environmental Choice Program requires the submission of an attestation of commitment to the objectives of the National Packaging Protocol. In support of this commitment, applicants are required to submit the following information:

(*i*) a copy of a packaging reduction action plan developed in accordance with the Packaging Audits and Packaging Reductions Workplans: Guidelines to help industry meet the goals of the National Packaging Protocol (EPC-NAPP-44E); or

(*ii*) a copy of a packaging audit or packaging reduction plan developed in accordance with applicable protocols or legislation; or

(*iii*) a completed questionnaire found in Appendix 2 of the *Canadian Code of Preferred Packaging Practices* (EPC-NAPP-35E).

If the applicant has not identified any measures currently applied to reduce packaging waste, either in terms of source reduction, reuse, recycling or composting, the applicant cannot be granted a license under this product category.

Any reference to a standard means to the latest edition of that standard.

Exigences générales

3. Pour que l'Éco-Logo puisse être apposé **produits de pellicule de polyéthylène doivent :**

a) être au moins conforme à toutes les no gouvernementales et industrielles applicables en m de rendement et de sécurité;

b) être fabriqués et transportés de telle façor toutes les étapes du processus, y compris l'élimin des déchets produits, soient conformes aux disposi de toutes les lois et de tous les règler gouvernementaux applicables, notamment, dans l des installations situées au Canada, la *Loi sur les p* et la *Loi canadienne sur la protection l'environnement (LCPE).*

Avis

Afin de diminuer la quantité de déchets solide préserver les ressources et de réduire les quantités incidences des substances toxiques et d'autres poll liés à l'emballage, le programme Choix environnem exige une preuve d'engagement à l'égard des object Protocole national sur l'emballage. Pour appuye engagement, les candidats doivent présenter ur documents suivants :

i) une copie d'un plan d'action visant la réd de l'emballage élaboré conformément au doc *L'audit d'emballage et le plan de réduction emballages : Lignes directrices pour l'atteint objectifs du Protocole national sur l'emballag l'entreprise* (EPC-NAPP-44F);

ii) une copie d'un plan de vérification o réduction de l'emballage élaboré conformément protocoles ou à la législation applicables;

iii) le questionnaire qui se trouve à l'annexe *Code canadien de bonnes pratiques d'emballage* aura été rempli (EPC-NAPP-35F).

Si le candidat n'a indiqué aucune mesure app actuellement pour réduire les déchets d'emballage, à la réduction à la source, à la réutilisation, au rec ou au compostage, il ne peut recevoir une licenc cette catégorie de produits.

Toute référence à une norme renvoie à la de édition de cette norme.

nvironmental Choice Program reserves the right to equivalent test data for the test methods specified in iideline.

Product Specific Requirements

To be authorized to carry the EcoLogo the hylene plastic film product must:

In order to be eligible for certification, hylene plastic film products must not be factured or printed with inks, dyes, pigments, or zers, or any other additives which contain lead, um, mercury, or hexavalent chromium.

To be eligible for certification, polyethylene film products must not be manufactured in a r that renders them technically non-recyclable.

To be authorized to carry the EcoLogo the ıylene plastic film product must meet the criteria : to its subcategory.

summary of the recycled content requirements ed in Subsections 5.1. through 5.10, refer to 1 at the end of the guideline.

Garbage bags must contain a minimum of:

20% post-consumer material;

of which at least 10% must be household nsumer material.

Grocery carry-out sacks must:

conform to the requirements of the PFMAC's *nance Test For Plastic Grocery Carry-out Sacks*;

contain a minimum of:

20% post-consumer material;

of which at least 10% must be household nsumer material.

Retail sacks must contain a minimum of:

20% post-consumer material;

Le programme Choix environnemental se réserve le droit d'accepter des données provenant d'essais dont les méthodes sont équivalentes aux méthodes prescrites dans cette directive.

Exigences particulières au produit

4. Pour que l'Éco-Logo puisse être apposé, les produits de pellicule de polyéthylène doivent :

a) Afin d'être éligible pour la certification, les produits de pellicule de polyéthylène ne doivent pas comporter d'encres, de colorants, de pigments ou de stabilisants pouvant contenir du plomb, du cadmium, du mercure ou du chrome hexavalent, ajoutés au cours de la fabrication ou par impression.

b) Afin d'être éligible pour la certification, les produits de pellicule de polyéthylène ne doivent pas être fabriqués de façon à être techniquement non-recyclables.

5. Pour que l'Éco-Logo puisse être apposé, les produits de pellicule de polyéthylène doivent satisfaire aux critères relatifs à la sous-catégorie dont ils font partie.

Un résumé des exigences relatives au contenu recyclé, précisées dans les sous-alinéas 5.1 à 5.10, est présenté au tableau 1, à la fin de la présente directive.

5.1 Les sacs à déchets doivent contenir un minimum de :

a) 20% de matières de postconsommation;

b) lequel doit comprendre au moins 10% de matières de post-consommation domestique.

5.2 Les sacs d'épicerie doivent:

a) être conformes aux exigences du *Performance Test For Plastic Grocery Carry-out Sacks* de la PFMAC, et

b) contenir un minimum de :

i) 20% de matières de postconsommation;

ii) lequel doit comprendre au moins 10% de matières de post-consommation domestique.

5.3 Les sacs de magasins doivent contenir un minimum de:

a) 20% de matières de postconsommation;

(b) of which at least 10% must be household post-consumer material.

5.4 Industrial shipping sacks must contain a minimum of:

(a) 25% recycled material;

(b) of which at least 10% must be post-consumer material.

5.5 Shrink film case wrap must contain a minimum of:

(a) 20% post-consumer material;

(b) of which at least 10% must be household post-consumer material.

5.6 Industrial stretch wrap must contain a minimum of 20% post-consumer material.

5.7 Drum and other liners must contain a minimum of:

(a) 50% recycled material;

(b) of which at least 20% must be post-consumer material;

(c) of which at least 10% must be household post-consumer material.

5.8 Construction films must contain a minimum of:

(a) 50% recycled material;

(b) of which at least 20% must be post-consumer material.

(c) of which at least 10% must be household post-consumer material.

5.9 Agricultural films must contain a minimum of:

(a) 20% recycled material;

(b) of which at least 5% must be household post-consumer material.

5.10 Agricultural mulch films must contain a minimum of:

(a) 25% recycled material;

(b) of which at least 5% must be household post-consumer material.

b) lequel doit comprendre au moins 10% matières de post-consommation domestique.

5.4 Les sacs-ballots industriels doivent con un minimum de:

a) 25% de matières recyclées;

b) lequel doit comprendre au moins 10% matières de post-consommation.

5.5 Les emballage de boîtes en pel rétrécissable doivent contenir un minimum de:

a) 20% de matières de postconsommation;

b) lequel doit comprendre au moins 10% matières de post-consommation domestique.

5.6 La pellicule rétrécissable industrielle contenir un minimum de 20% de matière postconsommation.

5.7 Les garnitures de fûts et autres garni doivent contenir un minimum de:

a) 50% de matières recyclées;

b) lequel doit comprendre au moins 20% matières de post-consommation;

c) lequel doit comprendre au moins 10% matières de post-consommation domestique.

5.8 Les pellicules de construction doivent co un minimum de:

a) 50% de matières recyclées;

b) lequel doit comprendre au moins 20% matières de post-consommation.

c) lequel doit comprendre au moins 10% matières de post-consommation domestique.

5.9 Les pellicules agricoles doivent conten minimum de:

a) 20% de matières recyclées;

b) lequel doit comprendre au moins 5% matières de post-consommation domestique.

5.10 Les paillis de plastique doivent conte minimum de:

a) 25% de matières recyclées;

b) lequel doit comprendre au moins 5 matières de post-consommation domestique.

Verification

To verify a claim that a product meets the criteria in the guideline, the Environmental Choice Program require access, as is its normal practice, to relevant y control and production records and the right of s to production facilities on an unannounced basis.

Compliance with section 3(b) shall be attested to signed statement of the Chief Executive Officer or equivalent officer of the manufacturer. The onmental Choice Program shall be advised in writing diately by the licensee of any noncompliance which occur during the term of the license. On the rence of any noncompliance, the license may be nded or terminated as stipulated in the license ment. In the event of a dispute related to the nsion or termination of the license, the license ment provides for arbitration.

Conditions for EcoLogo Use

The EcoLogo may appear on wholesale or retail ging, or on the product itself, provided that the ct meets the requirements in this guideline.

All licensees and authorized users must comply he Environmental Choice Program's *Guide to Proper f the EcoLogo*^{M} regarding the format and usage of coLogo.

Any accompanying advertising must conform with levant requirements stipulated in this guideline, the e agreement and the Environmental Choice m's *Guide to Proper Use of the EcoLogo*^{M}.

Vérification

6. Afin de vérifier l'assertion qu'un produit répond aux critères énumérés dans la présente directive, le représentant de Choix environnemental exigera, comme il le fait habituellement, l'accès aux dossiers de fabrication et de contrôle de la qualité pertinents, et réclamera le droit de visiter, sans préavis, les installations de fabrication.

7. Une attestation de conformité aux exigences énoncées à l'alinéa 3b) devra être signée par le chef de la direction du fabricant ou par le cadre qui remplit des fonctions équivalentes. Le licencié devra avertir immédiatement, et par écrit, le représentant de Choix environnemental de tout cas de non-conformité pouvant se produire durant la période de validité de la licence. Le cas échéant, celle-ci peut être suspendue ou révoquée, tel qu'il est précisé dans le contrat de licence. Ce contrat prévoit des dispositions concernant l'arbitrage dans le cas où le licencié en appelle de la suspension ou de la révocation de sa licence.

Modalités d'utilisation de l'Éco-Logo

8. L'Éco-Logo peut être apposé sur l'emballage de gros ou de détail, ou sur le produit lui-même, à condition que celui-ci soit conforme aux exigences de la présente directive.

9. Tous les licenciés et les utilisateurs autorisés doivent se conformer au *Mode d'emploi de l'Éco-Logo*^{M} du programme Choix environnemental concernant la présentation et l'utilisation de l'Éco-Logo.

10. La publicité d'accompagnement doit être conforme aux exigences applicables stipulées dans la présente directive, le contrat de licence et le *Mode d'emploi de l'Éco-Logo*^{M} du programme Choix environnemental.

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additional copies of this guideline or for more ution about the Environmental Choice Program, ntact TerraChoice Environmental Services Inc., rside Drive, Suite 300, Ottawa, Ontario, K1H 7X3, el: (613) 247-1900, Fax: (613) 247-2228.

Pour des exemplaires additionnels de la présente directive, ou pour des renseignements sur le programme Choix environnemental, communiquer avec TerraChoice Environmental Services Inc., 2197, promenade Riverside, bureau 300, Ottawa (Ontario), K1H 7X3, Téléphone: (613) 247-1900, Télécopieur: (613) 247-2228.

Table 1

Summary of Minimum Recycled Content Requirements/
Résumé des exigences de contenu recyclé minimum

Sub-Category/ Sous-catégorie	Minimum Recycled Content Requirements (%)/ Exigences de contenu recyclé minimum (%)		
	(a) Total Recycled Material/ Matières recyclées	(b) Post-consumer portion of (a)/ Part postconsommation recyclée du montant (a)	(c) Household post-consu portion of (b)/ Part postconsommati domestique du montant en (b)
Garbage Bags/ Sacs de déchets	not specified/ non précisé	20	10
Grocery Carry-out Sacks/ Sacs d'épicerie	not specified/ non précisé	20	10
Retail Sacks/ Sacs de magasins	not specified/ non précisé	20	10
Industrial Shipping Sacks/ Sacs-ballots industriels	25	10	not specified/ non précisé
Shrink Film Case Wrap/ Emballage de boîtes en pellicule rétrécissable	not specified/ non précisé	20	10
Industrial Stretch Wrap/ Pellicule rétrécissable industrielle	not specified/ non précisé	20	not specified/ non précisé
Drum and Other Liners/ Garnitures de fûts et autres garnitures	50	20	10
Construction Films/ Pellicules de construction	50	20	10
Agricultural Films/ Pellicules agricoles	20	not specified/ non précisé	5
Agricultural Mulch Films/ Paillis de plastique	25	not specified/ non précisé	5

Note: Post-consumer material includes household post-consumer material.
Note: Les matières de postconsommation incluent les matières de postconsommation domestique.

RESOURCE PLASTICS INC.

Appendix B

Release Date - March 1, 1995

MATERIAL PURCHASE SPECIFICATION
POST-CONSUMER TINTED LLDPE FILMS

COPE

ceptable materials consist of baled tinted or lightly printed (<5% surface area) post-consumer linear low nsity polyethylene films and liners. Each bale must contain a minimum of 98% of these materials. (The inition of post-consumer is outlined in ASTM D 5033-90, a copy of which will be supplied upon request.)

ONTAMINATION

ntaminants must be less than 2% of the shipment. Labels attached in the normal course of use are **not** sidered contaminants.

ne more common contaminants to be avoided are:

- (including rocks and stones)
- ns with any PVC or Saran
- avily printed or opaque films
- PE and/or LDPE film or bags
- ns contaminated with foodstuffs, oil, or grease
- Adhesive tape, twine, rope, or strapping
- Loose paper, corrugated and boxboard
- Wood
- Glass, metal, or rigid plastic containers
- Hazardous materials (see section III below)

min, free flowing liquids or objectionable odours **are prohibited**. The presence of these materials will be unds for rejection.

ZARDOUS MATERIALS

h supplier is solely responsible and liable for ensuring the absence of all hazardous materials. nibited materials include but are not limited to all materials which intentionally have been in contact with ides (as defined by Agriculture Canada), or which have been in contact with medical wastes, radio- opes, blood, blood products, bio-engineered products, pesticides, herbicides, or corrosive, toxic, reactive ammable materials.

LE AND SHIPMENT REQUIREMENTS

s must be uniform in dimensions and banded on the long side with galvanized steel or plastic h that the bales arrive at Resource intact. Typical bale dimensions are 48"X48"X72" with compaction sities at a minimum of 12 pounds per cubic foot. The baler should be cleaned from contaminants prior ling with plastic films. All materials must be stored in such a way as to protect them from sunlight.

hipments must be covered by a Resource Plastics Inc. purchase order. This PO number must be ly written on all shipping and invoice documents. In addition, all shipments must be accompanied by fied proof of weight, otherwise Resource generated weights will apply.

Please direct all inquiries to Ron MacElwee, Ann Newberry, or David Reck

This specification has been received and accepted

Signed:_____ Date:_____

ELGIN STREET; P.O. BOX 3688; BRANTFORD, ONTARIO N3T 6H2
ONTO: (905) 338-0823; (519) 754-1754/1755; FAX (519) 754-1742

RESOURCE PLASTICS INC.

Appendix B

Release Date - March 1, 1995

MATERIAL PURCHASE SPECIFICATION
POST-CONSUMER CLEAR LLDPE FILMS AND STRETCH WRAPS

I. SCOPE

Acceptable materials consist of baled clear post-consumer linear low density polyethylene films, liner and stretch wraps. Each bale must contain a minimum of 98% of these materials. (The definition of post consumer is outlined in ASTM D 5033-90, a copy of which will be supplied upon request.)

II. CONTAMINATION

Contaminants must be less than 2% of the shipment. Labels attached in the normal course of use are **not** considered contaminants.

Some more common contaminants to be avoided are:

Dirt (including rocks and stones)
Films with any PVC or Saran
Printed or opaque films
HDPE and/or LDPE film or bags
Films contaminated with foodstuffs, oil, or grease
Adhesive tape, twine, rope, or strapping
Loose paper, corrugated and boxboard
Wood
Glass, metal, or rigid plastic containers
Hazardous materials (see section III below)

Vermin, free flowing liquids or objectionable odours **are prohibited**. The presence of these materials will be grounds for rejection.

III. HAZARDOUS MATERIALS

Each supplier is solely responsible and liable for ensuring the absence of all hazardous materials. Prohibited materials include but are not limited to all materials which intentionally have been in contact with biocides (as defined by Agriculture Canada), or which have been in contact with medical wastes, radio-isotopes, blood, blood products, bio-engineered products, pesticides, herbicides, or corrosive, toxic, reactive or flammable materials.

IV. BALE AND SHIPMENT REQUIREMENTS

Bales must be uniform in dimensions and banded on the long side with galvanized steel or plastic such that the bales arrive at Resource intact. Typical bale dimensions are 48"X48"X72" with compaction densities at a minimum of 12 pounds per cubic foot. The baler should be cleaned from contaminants prior to filling with plastic films. All materials must be stored in such a way as to protect them from sunlight.

All shipments must be covered by a Resource Plastics Inc. purchase order. This PO number must be clearly written on all shipping and invoice documents. In addition, all shipments must be accompanied by certified proof of weight, otherwise Resource generated weights will apply.

Please direct all inquiries to Ron MacElwee, Ann Newberry, or David Reck

This specification has been received and accepted

Signed:_____ Date:_____

383 ELGIN STREET; P.O. BOX 3688; BRANTFORD, ONTARIO N3T 6H2
TORONTO: (905) 338-0823; (519) 754-1754/1755; FAX (519) 754-1742

RESOURCE PLASTICS INC.

Appendix B

RELEASE DATE- OCTOBER 1,1993

MATERIAL PURCHASE SPECIFICATION "BLUE BOX" HDPE BOTTLES

?E

cification outlines what will be considered acceptable material for recycling. Acceptable materials will consist of Post r Blow Moulded Mixed Colour/Natural High Density Polyethylene Bottles 0.1 to 5 litres in size and must comprise 98% ipment. The definition of Post Consumer is outlined in ASTM D 5033-90-3.1.7, a copy of which will be supplied on All bottles should be emptied and free of all contents. Acceptable bottles must be baled. This specification will comprise t of Schedule B to the Source Agreement, which shall constitute the total agreement between Resource and the Supplier.

TAMINATION

ıants are materials which cannot be used in our process and will comprise 2% MAXIMUM of the load. Said ants are described as but not restricted to the following (labels are not considered contaminants):

NCLUDING ROCKS AND STONES)	PAPER, BOX BOARD, CORRUGATED CARDBOARD
	ALUMINUM,STEEL OR BIMETALLIC CANS
T OR LAMINATED PP BOTTLES	WIDE MOUTH TUBS AND LIDS
Y SOILED HDPE BOTTLES	PAILS,CRATES AND LIDS

nd objectionable odours will not be tolerated and will be grounds for rejection of loads.

erials with contamination of between 2% and 5% will be subject to a deduction of the total contamination level with the final price paid. Loads with contamination levels above 5% will be subject to said deduction plus an additional cover land fill fees, currently $0.07/kg. Shipments which are deemed to be too contaminated will be returned to the reight collect.

RDOUS MATERIALS

ones safety, each contractor must ensure that their material suppliers are solely responsible and liable for removing all which intentionally have been in contact with biocides as described by Agriculture Canada or which intentionally or have been in contact with medical waste, radio-isotopes, blood or blood products or bio-engineered products.

s materials or containers which have contained corrosive, toxic, reactive or flammable materials will not be tolerated. ardous items are described as but not restricted to the following:

OIL CONTAINERS	DRAIN OR OVEN CLEANERS	PESTICIDES OR HERBICIDES
Y ACIDS	PAINT,VARNISH OR SOLVENTS	POOL CHEMICALS
L WASTE OF ANY KIND	SYRINGES OF ANY KIND	FLAMMABLE LIQUID CONTAINERS

AND LOAD REQUIREMENTS

must be uniform and durable. The dimensions must not exceed 48"X48"X60" banded on the long dimension. Banding galvanized steel or plastic. Bale densities should be 12 lb per cubic foot minimum. All materials must be stored in such so protect them from degradation from UV radiation (Sunlight).

PMENTS WILL BE COVERED BY A PURCHASE ORDER. THIS P.O. NUMBER MUST APPEAR ON ALL AND INVOICE DOCUMENTS

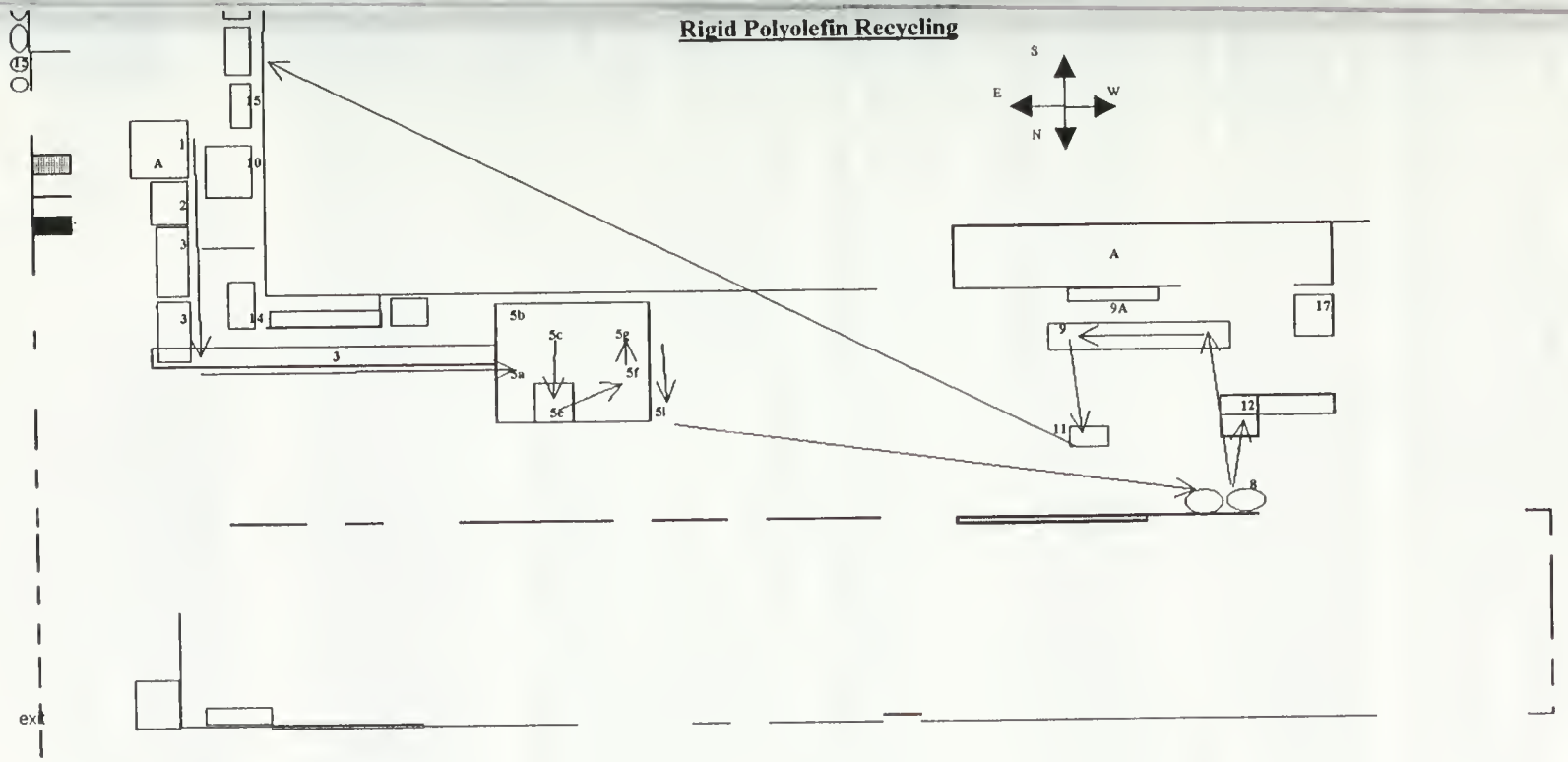
DIRECT ALL ENQUIRIES TO DAVID A. RECK - DIRECTOR OF SALES AND RIGID PROCUREMENT

CIFICATION HAS BEEN RECEIVED AND ACCEPTED SIGNED_____ DATE _____

ELGIN STREET: P.O. BOX 3688; BRANTFORD, ONTARIO N3T 6H2
ONTO: (416) 338-0823; (519) 754-1754/1755; FAX (519) 754-1742

Appendix C

Rigid Polyolefin Recycling



Total Area 40,000 sq. ft.

1A SORT BOX
1 BALE BREAKER(BOTTLES) PIERRET (FILM)
2 SORT LINE
3 CONVEYOR SYSTEMS

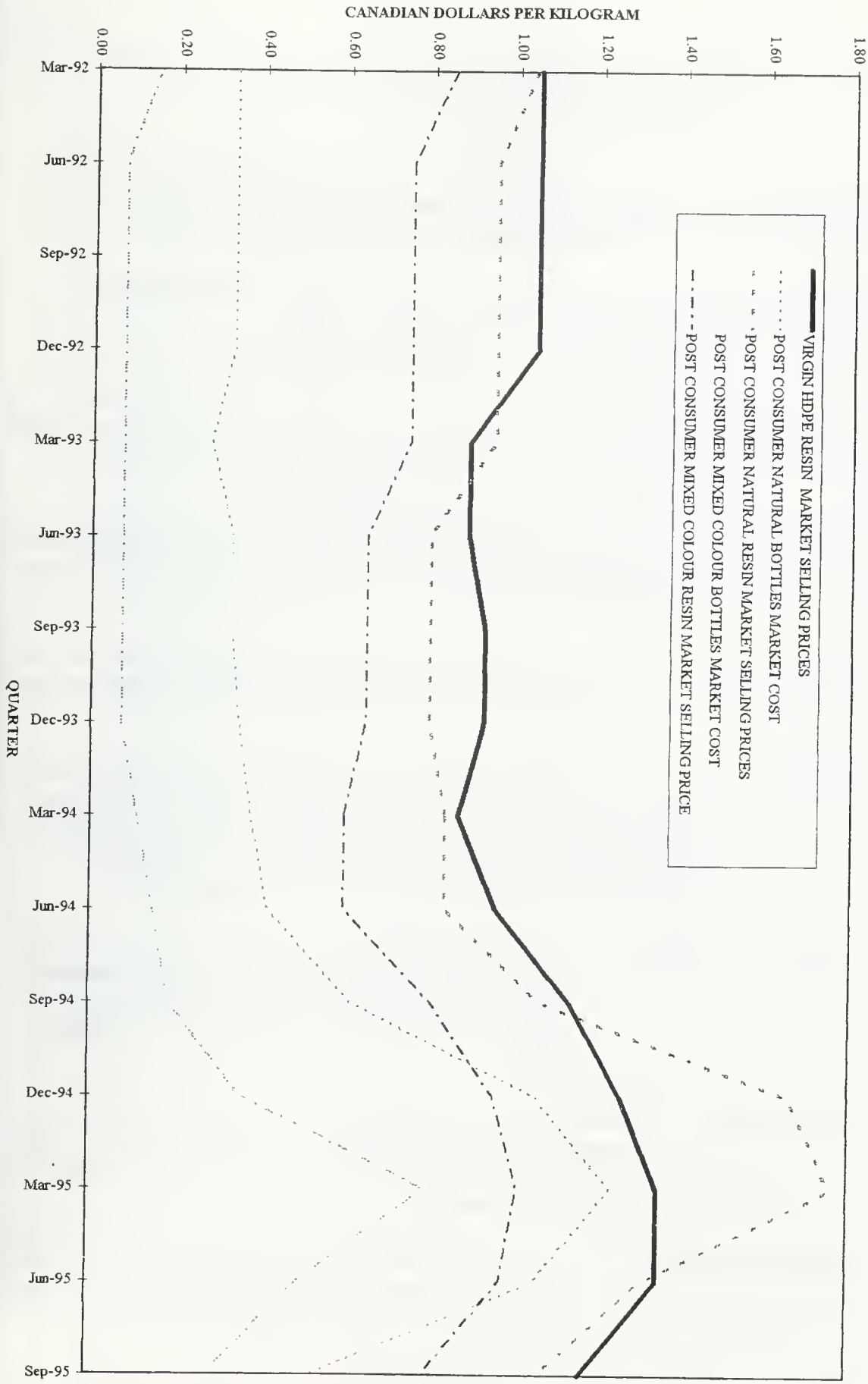
5 WASH LINE
5A PRE-WASH
5B PREVIERRO WET GRANULATOR
5C DE-WATER SCREWS.
5D BUFFER SILO
5E TURBO WASHER
5F HYDROCLONE TO PURIFY POLYOLEFIN
5G FRICTION SEPARATORS

5I THERMAL DRYERS

8 RIGID FLAKE STORAGE SILOS
9 "A" LINE COMPOUNDING EXTRUDER
9A CONTROL PANEL FOR "A" LINE
10 INSIDE STORAGE FOR RIGID MATERIALS
11 INSPECTION STATION
12 EREMA 80 EXTRUDER

15 STORAGE SILOS
16 BLENDING SILOS
17 BLOWN FILM LINE FOR QUALITY CONTROL TESTING.

Appendix D


COMPARISON OF HDPE VIRGIN TO PCR RESIN
CANADIAN DOLLARS PER KILOGRAM
0.00
0.20
0.40
0.60
0.80
1.00
1.20
1.40
1.60
1.80
QUARTER
Mar-92
Jun-92
Sep-92
Dec-92
Mar-93
Jun-93
Sep-93
Dec-93
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
VIRGIN HDPE RESIN MARKET SELLING PRICES
POST CONSUMER NATURAL BOTTLES MARKET COST
POST CONSUMER NATURAL RESIN MARKET SELLING PRICES
POST CONSUMER MIXED COLOUR BOTTLES MARKET COST
POST CONSUMER MIXED COLOUR RESIN MARKET SELLING PRICE

Phase II, Stages 1 and 2
WISH LIST FOR R & D PROJECTS

Appendix E

Wish List issued to the Universities of Toronto, Waterloo, Queen's and McMaster and also the National Research Council Laboratories in Ottawa and Boucherville, PQ.

The following is a list of some of the problems.

1. Odour - A major problem in milk bottle waste and an even worse problem with perfumes from detergents, shampoos, etc.

2. Adhesives - Removal of all traces of label adhesives on the polyolefin is a very difficult problem. We suspect that adhesive residues create or promote gel formations, dirt carry over and resin discolouration.

3. Ink removal - Another serious problem, as inks are printed on plastic products, often with thermosets, and these are incompatible with thermoplastics and discolour the polyolefin.

4. Surface chemistry - How clean is clean? We need to know more about minute levels of contamination and what problems they create in downstream melt processing.

5. Separation - It is imperative that we are able to provide single stream polymers in order to meet quality targets. The problems relate to separating wood, paper fibres, PVC, PVDC, PET from polyolefins. It would also be helpful to be able to separate HDPE from L or LLDPE, and PP. Some we do reasonably well with hydrocyclones, but is there a better way?

6. Polymer Feed Separation - Bale breaking and sorting, by polymer type, by colour and by molecular weights at 2 tonnes per hr in an automated system working with mixed baled feedstock containing HDPE, L or LLDPE, PP, PVC, PS, PET and perhaps others.

7. Water Quality - What is the effect of wash water quality temperature and surfactants or sodium hydroxide on the cleaning process. What impact does the hardness of the water have on polymer quality and possible gel formation.

8. Herbicides/Pesticides - Is there any economical way to remove traces (to acceptable standards) of these materials from the molecular structure of HDPE?

9. Environmental Health - What areas might the recycling industry have to consider? Better to consider the issue now, not later. We currently inoculate employees against Hepatitis B.

10. Gels - Do we know the mechanisms of gel formation in polyolefins when using waste plastic feed streams? Gels are basically high molecular weight lumps. They are tiny but create problems in film production.

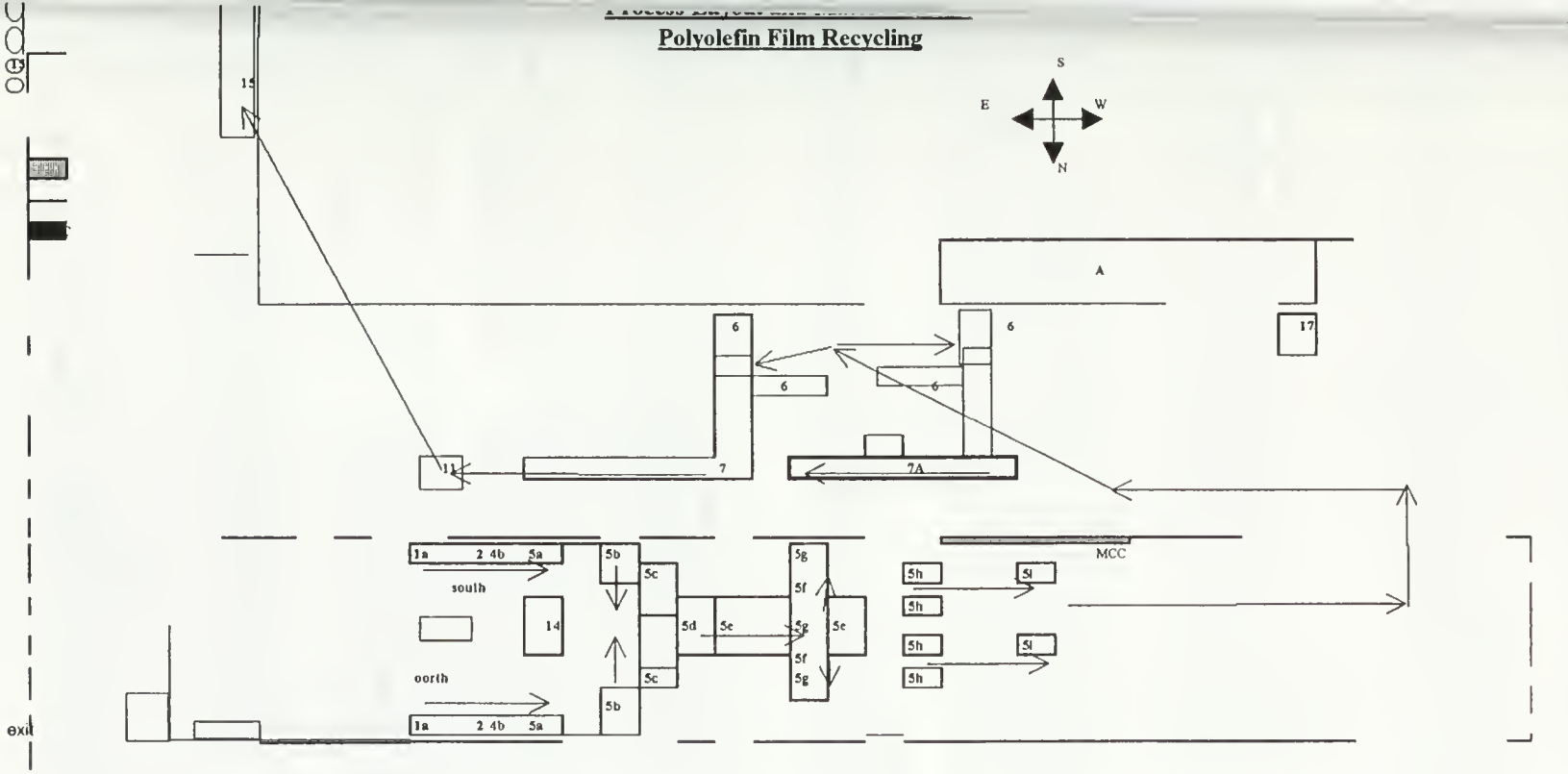
11. Compatibilization - What economic systems might be studied to reasonably blend some mixtures of polymers and divert them from the waste stream. A case in point would be polyethylene/polypropylene mixtures.

12. Equipment design - What extruder screw designs work the best with a recycled polymer stream? Can we model them and their performance before we build them?

13. On Line QC - Are systems available to detect possible QC problems on line, i.e. dirt, gels, PVC, PET, etc. (Dr. Steve Balke, at the University of Toronto, is working with near infra red on this one).

Appendix F

Polyolefin Film Recycling



Total Area 40,000 sq. ft.

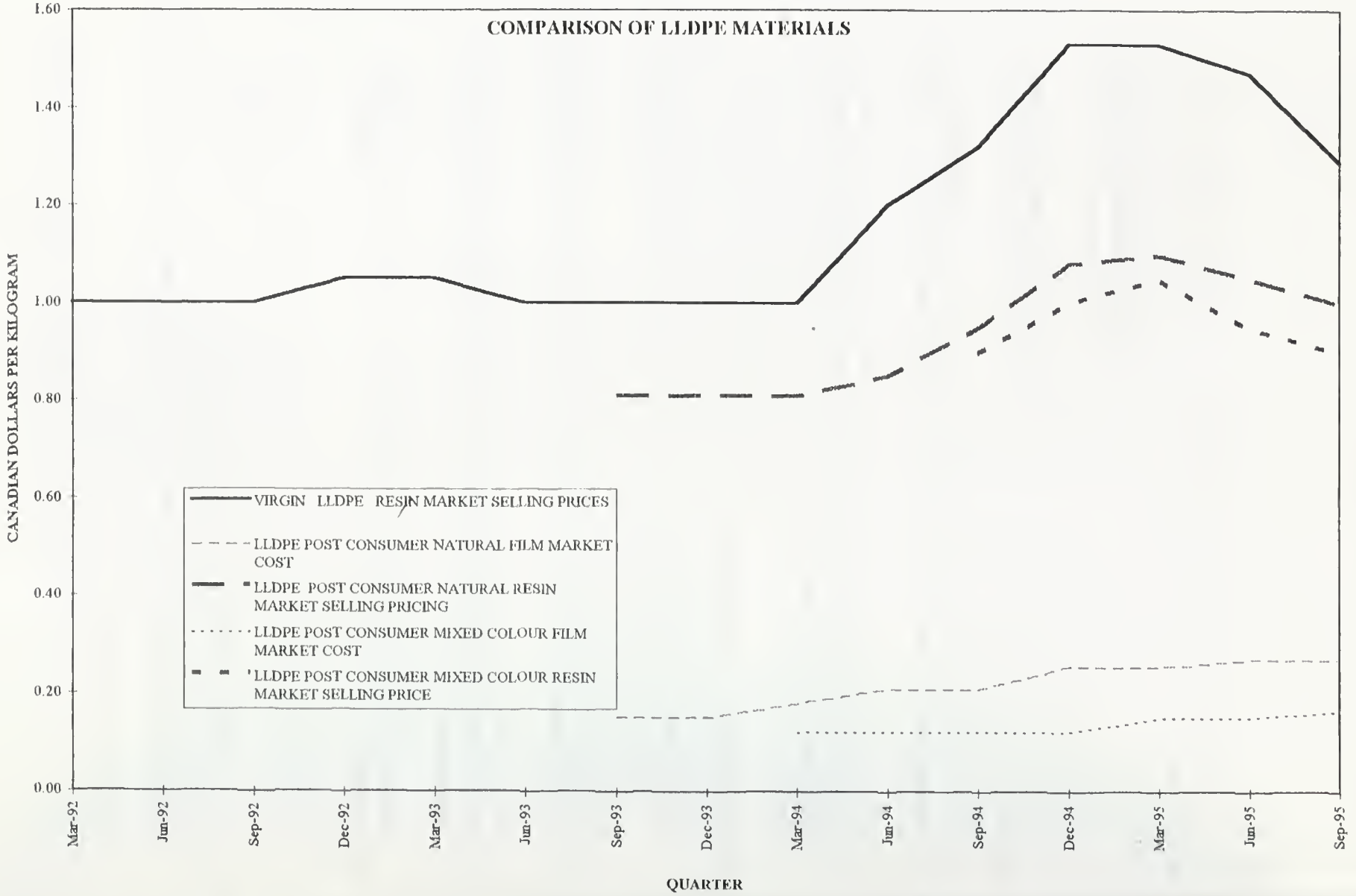
1A SORT BOX
1 BALE BREAKER(BOTTLES) PIERRET (FILM)
2 SORT LINE
3 CONVEYOR SYSTEMS
4B CT 60 CUTTERS
5 WASH LINE
5A PRE-WASH
5B PREVIERRO WET GRANULATOR
5C DE-WATER SCREWS.
5D BUFFER SILO
5E TURBO WASHER
5F HYDROCLONE TO PURIFY POLYOLEFIN
5G FRICTION SEPARATORS
5H MECHANICAL DRYING SYSTEMS
5I THERMAL DRYERS

6 FLAKE SILO STORAGE/FEEDING FOR
7 EREMA 160E
7 A EREMA 160VE

11 INSPECTION STATION

14 WATER TREATMENT WASH LINE TWO
15 STORAGE SILOS
16 BLENDING SILOS
17 BLOWN FILM LINE FOR QUALITY CONTROL TESTING.

Appendix G


COMPARISON OF LLDPE MATERIALS
CANADIAN DOLLARS PER KILOGRAM
1.60
1.40
1.20
1.00
0.80
0.60
0.40
0.20
0.00
VIRGIN LLDPE RESIN MARKET SELLING PRICES
LLDPE POST CONSUMER NATURAL FILM MARKET COST
LLDPE POST CONSUMER NATURAL RESIN MARKET SELLING PRICING
LLDPE POST CONSUMER MIXED COLOUR FILM MARKET COST
LLDPE POST CONSUMER MIXED COLOUR RESIN MARKET SELLING PRICE
Mar-92
Jun-92
Sep-92
Dec-92
Mar-93
Jun-93
Sep-93
Dec-93
Mar-94
Jun-94
Sep-94
Dec-94
Mar-95
Jun-95
Sep-95
QUARTER

GLOSSARY OF TERMS

Appendix H

- Acrylic coated polyethylene film (a technique used to promote high speed sealing).

- American Society for Testing Materials (ASTM). A group of stakeholders that establishes testing standards and test methods.

- Angstrom - a millionth of a millimetre

- Biological Oxygen Demand (BOD). A measure of the oxygen required to deal with the residual milk products released during the wash cycle from recycled milk bottles.

- Chemical Oxygen Demand (COD). A measure of the oxygen required to deal with detergents and other cleaning products remaining in the bottles and released in the wash cycle in the water going to the municipal sewer.

- Environmental Choice Program - a program set up by the Government of Canada to promote the use of products that meet stringent conservation guidelines (see ECOLOGO).

- The Environmental and Plastics Institute of Canada (EPIC). A plastic industry organization in Canada organized to address environmental issues related to plastics.

- ECOLOGO - a trademark of the Environmental Choice Program that denotes products that meet very stringent conservation guidelines.

- Ethylene vinyl alcohol (EVOH) - a polymer used as an oxygen barrier on multilayer bottles (ie Heinz Ketchup bottles). The EVOH is extruded as the inner layer, often with polypropylene as the two outer layers.

- High Density Polyethylene (HDPE). Polyethylenes generally with densities in the 0.095 to 0.98 gms/cc range.

- Hydroclones - primarily a hydraulic cyclone used to sort materials of different densities carried in a water stream.

- International Standards Organization (ISO). An international body that establishes standards and test methods.

- Linear low density polyethylene (LLDPE). Polyethylene generally with densities in the 0.92 - 0.93 gms/cc range but with a more linear molecular structure that LDPE.

- Low Density Polyethylene (LDPE) Polyethylenes generally with densities in the 0.92 - 0.93 gms/cc range. Sometimes referred to as high pressure, low density polyethylene because of the manufacturing process used.

- Metallized films. This is a technique using a vapourized metal (ie. aluminum) deposited on a plastic film in a very thin layer to provide a gas barrier for product protection such as is used in snack food bags. Such films can be recycled.

- Polyolefins. A generic term describing polymers such as polyethylene, polypropylene and polybutylene.

- Polypropylene (PP). A polymer with a density of 0.905 gms/cc used in textiles, packaging films, caps and closures, auto parts, battery cases etc.

- Polyvinylchloride (PVC). A widely used polymer with a density of about 1.4 gms/cc. It is widely used in construction applications sch as pipe and building siding. The packaging markets would use it for blister packaging, bottles and film.

- Polyvinylidenechloride (Saran ™). Saran is a trademark of the Dow Chemical Company. It is used as an extrusion coating film, providing excellent gas barrier properties. It is also used as a food wrap film. It has a density of about 1.4 gms/cc.

- Post consumer resin (PCR) means a product which has served its end-use at the consumer level, has been discarded by the consumer, and would, unless diverted, enter the waste stream. This includes household post-consumer recycled (HPCR) material

- Pre consumer material means materials generated by an industrial process that would, unless diverted, enter the waste stream. This includes, but is not limited to damaged or defective materials, overstock or obsolete inventories from manufacturers, distributors, and wholesalers. It does not include industrial scrap.

- Recycled material means post-consumer material and pre-consumer material. It does not include industrial scrap, except that proportion of the scrap which originated as post-consumer material and pre-consumer material.

- The Society of the Plastics Industry of Canada (SPI Canada). An industry group dedicated to addressing issues arising in this sector.

- SORTCO - an acronym for a sorting company proposed by members of the Canadian plastics industry. This would take in mixed bales of curbside collected plastics and do a full sort.

- Tonne - a metric tonne, 1000 kg or 2204 pounds.

- Trommels - usually a large drum perforated with holes to separate materials of different sizes as it rotates.

- Tyler Mesh - An industry term that describes mesh sizes in a sieve. For example a 150 Tyler mesh size has 105 micron openings. A 100 Tyler mesh size has 149 micron openings in the wire mesh. These follow an ASTM standard E-11-61.